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ALFRED WERNER

EDITOR'S OUTLOOK

IN 1913 the Swedish Academy of Sciences summoned to Stockholm, among other notables, the Alsatian-born, German-bred, Swiss scientist, Alfred Werner, to confer upon him the Nobel award in chemistry "in recognition of his works on the linking up of atoms within the molecule, whereby new light has been thrown upon older fields of research, and new fields have been opened up, especially within the realm of inorganic chemistry." The award was presented by the king of Sweden, and it used to please Werner to record the romantic coincidence that, as a youthful volunteer in the army at Karlsruhe, in the days when he was at the same time acquiring a part of his early chemical training, he often did sentry duty before the palace of the Princess Victoria, at whose court, as queen of Sweden, he was received into the ranks of scientific peerdom.

Alfred Werner, 1866-1919

Werner was born at Mülhausen on December 12, 1866. His genius for chemistry exhibited itself at an early age, so that the small income he acquired from boyish chores was invariably expended for chemical supplies and apparatus. At the age of eighteen, he presented to Noelting, professor at the technical school which he attended in his native town, the report of his first independent chemical investigation, accompanied by an inquiry as to how long it would take to become a professor. Noelting's reply to the naive question mingled encouragement with wholesome advice, but indeed it was not to take this extraordinary student so long to attain his ambition. At the age of twenty-seven he succeeded Victor Merz as "extraordinarius" at the University of Zürich, and two years later he became regular professor. This whirlwind professional advancement was the happy crowning of a nine years' interim of intensive work, first as a student, later as an assistant in the Allied Polytechnic of Zürich, under the eminent teachers Lunge, Hantzsch, and Treadwell, and, finally, after receiving his doctorate from the University of Zürich, in post-graduate work under Berthelot at the Collège de France in Paris.

His youth rendered his relations delicate with professors and students alike, but he managed the situation with extreme tact, an amiable disposition aiding his brilliant intellectual gifts in making him from the beginning a successful teacher. His interests in chemistry at the time covered both the organic and inorganic fields. His reading in both was so extensive and his memory so vast and sure, that in the "discussion-evenings" which he inaugurated at Zürich as part of his early attack on the problems peculiar to his teaching appointment, his students found it difficult to meet his demands upon them, and no doubt submitted with a poor grace in the beginning to an intellectual contact which they later learned to estimate at its true worth.

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not only professional but personal, and it was one of his remarkable characteristics that he achieved and maintained both relationships while directing a phenomenal number of research students and that the friendships thus formed continued through his life. Each year his students gave a Christmas party in his honor, and it was Werner's delight that at each of these events the pupils who had passed from his charge into independent work came back to honor their old master.

Werner's earliest publications foreshadowed the revolutionary influence he was to exert on his science. His dissertation for the doctorate, "On the Spatial Arrangements of Atoms in Compounds Containing Nitrogen," gave evidence of an originality and a mental range beyond the average, and in his inaugural paper on his return to Zürich in 1892, "Contributions to the Theory of Affinity and Valence," is much of the substance of the important material he was to refine and make available to science in later years. This was followed by the particularly important "Contribution to the Constitution of Inorganic Compounds," which threw a new light on the conception of valence. Shortly after this Werner completely gave up his interest in the organic field and devoted himself entirely to inorganic chemistry. Some of his notable contributions are: establishing the stereochemistry of nitrogen compounds; advancing the coördination theory with the idea of coördination number, the secondary valence, the direct and indirect bonds, and the system of inorganic compounds developed out of the theory; establishing the stereochemistry of metal compounds through the detection of geometric and optical isomeric compounds of cobalt, chromium, platinum, iron, and rhodium; advancing ideas regarding metal hydration; developing new ideas about the nature and course of substitution processes and the Walden inversion.

In 1916 Werner was attacked by a fatal malady which forced him to give up gradually but surely the responsibilities and activities that were so dear to him. After four years of distressing illness, he died on November 15, 1919. Although he was thus prematurely cut off in his fifty-third year, it may well be said that to few men has life given a satisfaction or from them received a service so complete. For the latter the list of his scientific work speaks for itself. As to his domestic and civic relations, they were particularly happy. He was a devoted husband and father, and his family affections soon spread to include the Swiss fatherland of his wife and children. He became at the time of his marriage a Swiss citizen in fact as well as in name, and his attachment to Zürich became so deep and strong that many flattering calls to other universities, with greater promises of opportunity, held no attraction for him. At Zürich he remained, and he was repaid for this loyalty when, during the World War, the maintenance of neutrality in the country of his adoption permitted him to stand aside from the painful conflict in which he would

have had to pit a cultural sympathy with his native land against his intellectual debt to Germany. He was spared the decision and passed the unhappy war years in an uninterrupted pursuit of a work that was to be complete even in incompletion.

The JOURNAL OF CHEMICAL EDUCATION *acknowledges its gratitude to Dr. K. Freudenberg, its foreign editor for Germany, for the accompanying portrait of Werner, and to Dr. P. Karrer, of the Chemisches Institut der Universität Zürich, for much of the material upon which this sketch is based.*

"Education for Leadership"

WE MUST confess that we experience a childlike delight whenever some unruly person applies a pin to a well-inflated balloon. In the way of light intellectual diversion we find nothing quite so entertaining as the collapse of a high-sounding phrase which signifies nothing. By way of sharing our innocent pleasures we present the following quotations from Professor Snedden's latest exploit in bladder-bursting:[1]

> Educators talk much these days about "education for leadership." The phrase sounds well, but it is a rare writer who undertakes to explain what it means . . . . . .
>
> The thesis is here submitted that educators and others of the *intelligentsia* who freely use the terms "leadership" and "education for leadership" are in reality lending themselves to the somewhat soporific effects of certain mythical conceptions deriving from medieval habits of mind . . . . .
>
> Untutored minds still retain strong dispositions to ascribe omniscience to men in high places. The opinions of university presidents are eagerly sought on questions having nothing to do with college administration. The chance utterance of a multi-millionaire or a motion picture actress on religion or education is published and republished to the world.
>
> The unmodified use of the term "leader" connotes for too many people possession of a quiver of superior powers far beyond what the cold facts warrant. Even schoolmen have been heard to assert that a "capable" principal of a high school should be able to teach any class in that school better than the appointed teacher. Perhaps he should be able to sing better than the teacher of music or kick a football better than the athletic coach? . . . .
>
> One harmful product of our still surviving attitudes toward leadership is the mental and emotional habit of regarding the human world as composed of a small number of leaders and a large number of followers. In a realistic sociological sense, however, all persons beyond early childhood are in some relationships followers and in others leaders. . . . . .
>
> It would probably be much more scientific for current students of social, including educational, phenomena to drop the general terms leader and leadership as technical designations and substitute words denotive either of very concrete types of leadership or, better still, to seek terms denoting particular kinds of specialization.
>
> Two conditions of specialization of productive service are, obviously, of great importance in the complex societies of today. First, each worker should be helped to find that rôle for which his natural and already acquired qualities best fit him. Sec-

[1] "Aspirational Notions of Leadership," *Sch. & Soc.*, **31**, 661–4 (May 17, 1930).

ondly, in the exercise of that rôle he should have all the authority over others which is essential to the effective discharge of his specialized functions. . . . . .

Similar considerations apply to functions of "followership." In a fundamental sense legislators, bishops, political party leaders, editors, and naval officers are followers in hundreds of relationships in life no less than are school children, factory working girls, or field hands. Toward social and other kinds of harmony and effectiveness, obviously, it is important that each person shall keenly realize his "followership" responsibilities, and shall loyally and obediently live up to them—and also permit no invasion of his personal reserves because of his present rôle of followership.

It is now too late for this year's crop of commencement orators to profit by this re-hash of Professor Snedden's brief essay. Let us hope that some of them read it in the original and refrained from springing one or two of their time-honored gags.

There was a time when "education for leadership" had a certain ring of plausibility about it, especially for audiences which had just undergone the process. The relatively small number of college graduates, together with the somewhat selected nature of such groups, inclined one to give the notion serious consideration. But of late it has become apparent that if the idea is valid we must be training armies of generals to lead only slightly smaller armies of enlisted men. We are glad that some one has attempted a more rational analysis of the realities.

Taps

IN THIS present age, when politics are no longer looked upon in the noble light of our forefathers and their service and unselfish purpose for public good are somewhat obscured, it is gratifying to find in the field of chemistry one who held a high place in the Federal Government and to whom the people at large owe much.

Dr. Harvey Wiley,* who died at his home in Washington, D. C., on June 30th last, for nearly thirty years chief chemist of the Bureau of Chemistry, is universally known as the "Father of the Pure Food Law." The period of his administration was so bitter and his advances so hard-fought, that one writer has referred to it as a "Thirty Years' War." His enemies were many and prominent; nor were important friends lacking, for we find President Taft a staunch supporter. Even after his resignation he kept strict watch on this department of the government.

We find this indomitable scientist, who started his career as a professor of Latin and Greek at an Indianapolis college, active in other projects, two of which were the beet- and cane-sugar industries in our country. He is the author of several books relating to food chemistry.

His passing has brought numerous reminiscences testifying to his courageous and likable personality.

* Dr. Wiley's portrait may be found as the frontispiece to the JOURNAL OF CHEMICAL EDUCATION for August, 1927.

THE DIALYZER

1. Who was the winner of the Nobel Prize in chemistry for 1913? In recognition of what work was this award made? (pp. 1732–5.)
2. Who is universally known as the "Father of the Pure Food Law"? (p. 1736.)

(*For questions* 3–7 *see* pp. 1738–62.)

3. How did the Egyptians make paper from papyrus?
4. When and by whom was paper making introduced into Europe?
5. When and where was the first paper mill established in America?
6. How do the present-day raw materials for paper making differ from those of 100 years ago?
7. Outline briefly the four commonly used methods of pulp-making.

8. What relation exists between cholesterol and the bile acids? What two German investigators are responsible for the establishment of this relation? (pp. 1763–77.)

(*For questions* 9–11 *see* pp. 1778–87.)

9. What is the origin of the quantum theory?
10. Outline briefly Bohr's theory of energy levels.
11. What difficulties arise in applying classical mechanics to atoms?

(*For questions* 12–14 *see* pp. 1788–1801.)

12. Who named rubber and when?
13. What effect did Goodyear's discovery of vulcanization have upon the commercial development of rubber?
14. What two men worked out together a successful method for transforming low-tensile to high-tensile rubber? How did they accomplish this?

(*For questions* 15–20 *see* pp. 1802–49.)

15. What effect has chemistry had upon the cotton industry of our country?
16. What is the present generally accepted structural formula for cellulose?
17. What relation exists between cotton and the synthetic fibers?
18. What factors determine the properties of the rayon fiber?
19. What characteristics of cellulose nitrate make it suitable for use in the lacquer industry?
20. How has the status of cotton as a source of cellulose changed during the development of the explosives industry?

21. What are the chief by-products of the peanut industry? (pp. 1859–68.)
22. Name four objectives, the attainment of which would increase the value of our general chemistry courses. (pp. 1869–75.)
23. How has the chemistry department of Wesleyan University met the student smoking problem of the laboratory? (pp. 1878–86.)
24. What are the advantages of the Library of Congress classification for a chemistry library? (pp. 1887–94.)
25. What effects do temperature and concentration of acid have on the rate of generation of hydrogen sulfide? (pp. 1901–9.)
26. What three kinds of water exist in the ocean? (p. 1921.)
27. When and where is the next meeting of the American Chemical Society to be held? (pp. 1926–7.)
28. What are "live" chemical museum exhibits? (pp. 1936–7.)
29. What steps are being taken to preserve the birthplace of Pasteur? (p. 1975.)

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THE SPRUCE FORESTS SUPPLY MOST OF THE PULP FOR PAPER MANUFACTURE IN THIS COUNTRY

In the woods most of the work is now done with donkey engines and modern pulleys, but the woodsman still plays a large part.

THE STORY OF PAPER

H. K. Benson, University of Washington, Seattle, Washington

Paper Making Prior to the Nineteenth Century

The art of story telling is ancient and honorable. In primitive peoples the duty of transmitting the legends and traditions of a tribe was sacred and reverential. It found expression in the markings on rocks and on tablets of clay which were later hardened by baking in the sun or burning in fire. Thin boards of wood covered with wax and plates of ivory or metal were also used. The skins and intestines of animals were also made fit for writing upon; and there still exists in the Sorbonne in Paris a manuscript, certified by an ancient librarian to be written upon human skin; as well as an elegant copy of the Bible which, according to the Abbé Rive, was written on the skin of a woman. More generally the use of the skins of sheep and goats, dressed in much the same manner as for leather but stretched in frames and rubbed with pumice, constituted the parchment mentioned by Herodotus as being common among the Ionians at 500 B. C. Its most familiar form in modern times is the "sheepskin" awarded to the faithful few who are so fortunate as to complete a college education.

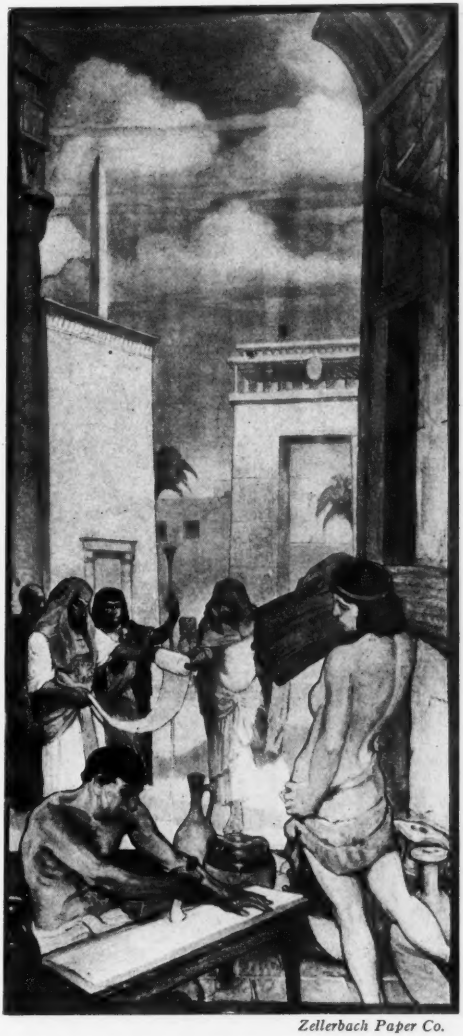

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Figure 1.—Making Paper from Papyrus in Ancient Egypt

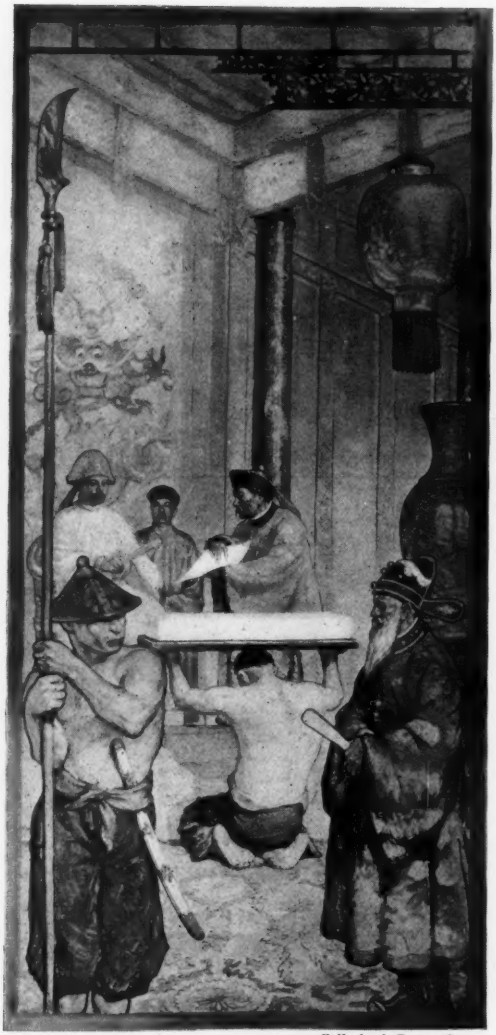

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FIGURE 2.—PAPER MAKING IN CHINA

For 600 years the Chinese carefully guarded their process of beating bamboo and old rags to pulp and compressing it into sheets.

The principal competitor of parchment was the Egyptian papyrus plant, the cellular stem of which was separated by means of mussel shells into strips, placed side by side in a frame and over the layer thus formed similar strips were laid crosswise, sprinkled with water, pressed, and dried. These sheets were later rubbed and polished with shells and produced through the aid of its natural gum a smooth and homogeneous surface. Figure 1 depicts the making of paper from papyrus, which was made into rolls such as that in the hands of the Egyptian nobleman shown. The slave in the foreground is shown trimming a piece of papyrus ready for the making of a scroll. The antiquity of papyrus scrolls reaches back to 3600 B. C.

The center of the Egyptian paper trade was Alexandria and that city acquired great riches therefrom. It supplied Europe and Asia for several centuries, reaching its maximum during the third and fourth centuries and continuing to the eleventh century, at which time the use of parchment and of paper made

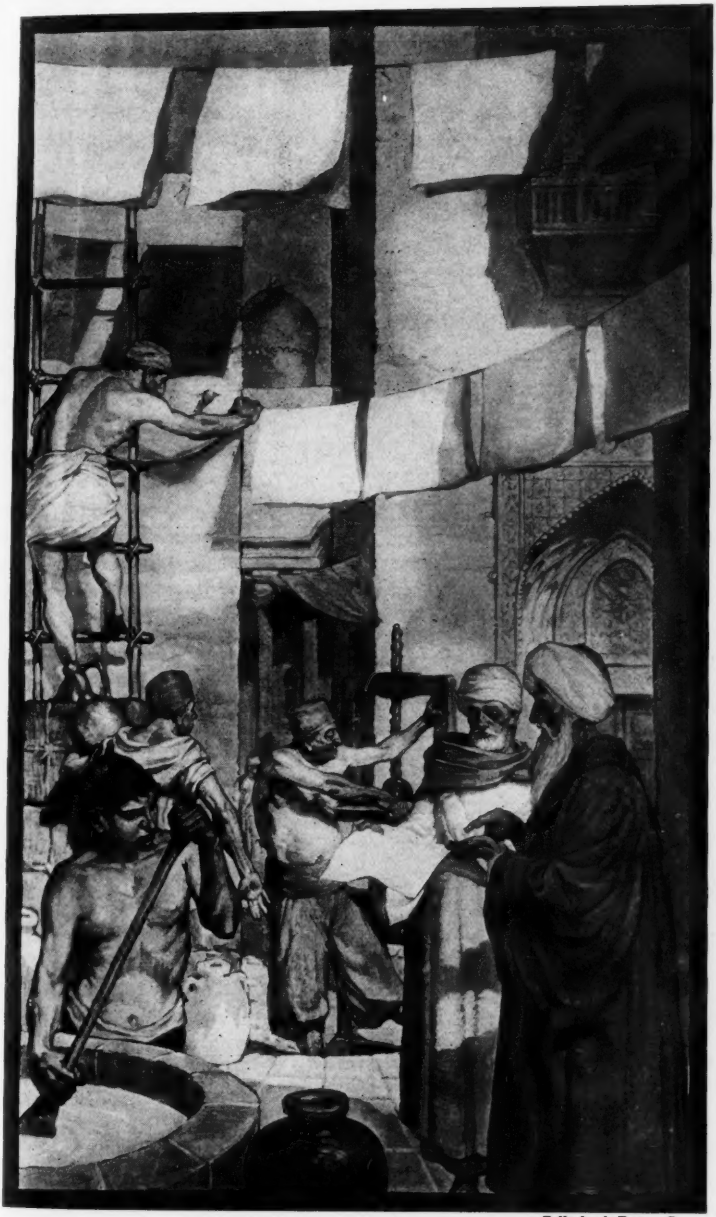

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FIGURE 3.—MAKING PAPER IN ANCIENT BAGDAD WHERE IT WAS INTRODUCED BY CHINESE PAPERMAKERS CAPTURED BY THE ARABS

This picture shows the open vat in which the pulp was macerated, the crude hand press then used, and the manner in which they dried the finished sheets.

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FIGURE 4.—SPANISH NOBLEMAN OF THE ELEVENTH CENTURY EXAMINING PAPER MADE BY THE MOORS

from cotton superseded it.

The invention of paper from fibrous matter suspended in water must be credited to the Chinese at the time of the Christian era. Figure 2 depicts the presentation of the first true paper to the Chinese Emperor. The Chinese made the paper from the inner bark of the mulberry tree by the method still in use by the Japanese to some extent at the present time. The bark is removed from the tree, soaked in water, the inner bark removed from the outer bark and dried in the sun. It is next boiled with lye obtained from leaching wood ashes. After washing with water it is beaten into a pulp with long wooden mallets (Figure 3); after which it is suspended in water and formed into sheets on a sieve of bamboo strips. By dipping the sieve into a tank of the suspended pulp and shaking the sieve, the water drains off, leaving a sheet of uniform thickness, with the fibers interwoven and felted in all directions. The sheet is then removed and dried in the sun. The simple method thus described is essentially the method used in modern paper making, but since the mulberry tree does not grow in Europe it was necessary to find other fibers which required machinery rather than hand power

for their preparation as stock for paper making.

The introduction of paper making into Europe in the 8th century came by way of Spain where the Moors were the paper makers (Figure 4). They had learned it from the Hindoos and the Chinese. They substituted cotton, linen, and hemp for the mulberry bark of the Chinese. Upon the expulsion of the Moors, the Spaniards extended the manufacturing to old worn-out cotton and linen rags. From Spain, the art of paper making spread (Figure 5) into France, Italy, Austria, and Germany. As late as 1690 there were only a few mills in England and Holland. In this year the first paper mill was established in the colonies by a German paper maker, William Rittenhause, and an English printer, William Bradford of Philadelphia. It must be remembered that newspapers did not exist until after 1700. Prior to this time the needs of the colonists were easily supplied by importations from Europe.

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FIGURE 5.—THE FIRST PAPER MILL ERECTED IN GERMANY IN 1336

In America the raw material for the paper industry consisted of cotton and linen rags and the uncertainty of a sufficient supply must have always made the industry insecure. Consequently, we find many evidences of

the skill employed by purchasing agents to insure an adequate supply of rags for their respective mills. Thus in the *Boston News Letter* in 1769 appeared the statement (*6*) that "the bellcart will go through Boston before the end of next month, to collect rags for the paper mill at Milton when all people that will encourage the paper manufactory may dispose of them;" and as a further encouragement the following lines were appended:

"Rags are as beauties, which concealed lie,
But when in paper how it charms the eye;
Pray save your rags, new beauties to discover,
For paper, truly, every one's a lover:
By the pen and press such knowledge is displayed,
As wouldn't exist if paper was not made.
Wisdom of things mysterious, divine,
Illustriously doth on paper shine."

Yet, in spite of poetic appeals, there was a constant scarcity of paper in the colonies, so much so that files of soldiers had to be sent out to search the houses in Philadelphia to find paper suitable for the construction of cartridges. It is related that in the attic of the house where Benjamin Franklin had previously had his printing press they found 2500 copies of a sermon, the paper of which was used as cases for musket cartridges in the battle of Monmouth.

After the Revolution, the paper-making industry made more rapid progress, one hundred and eighty-five mills being in operation in 1810, but the efforts to secure the raw material for new mills were as heroic as ever. Upon the erection of a new mill in New York state the following appeal was made (*7*):

Save your rags! This exclamation is particularly addressed to the ladies, both young, old, and middle aged, throughout the northern part of this state, by the subscribers, who have erected a paper mill in the town of Moreau near Fort Edward—nor is it thought that this appeal to our fair countrywomen will prove unavailing when they reflect that without their assistance they cannot be supplied with the useful article of paper. If the necessary stock is denied paper mills, young maids must languish in vain for tender epistles from their respective swains; bachelors may be reduced to the necessity of a personal attendance upon the fair, when a written communication would be an excellent substitute. For clean cotton and linen rags of every color and description, matrons can be furnished with Bibles, spectacles, and snuff; mothers with grammars, spelling books, and primers for their children; and young misses may be supplied with bonnets, ribbons, and earrings, for the decoration of their persons (by means of which they may obtain husbands), or by sending them to the said mill they may receive the cash.

At this time paper making from rags was a well-developed industry, with about 500 mills in Germany; the same number in France; while the value of paper produced annually in Great Britain exceeded a million pounds sterling. In the United States census reports to Congress in June, 1813 (*13*), were listed 202 mills producing 425,521 reams of paper valued at

$1,689,718. More than half of these mills were in New York, New Jersey, and Pennsylvania, sixty in New England, while those remaining were scattered in nine smaller states and territories.

Introduction of Machinery to Paper Making

At the beginning of the nineteenth century hand processes of paper making were used almost entirely, although various mechanical devices were invented and employed to some extent. The rags after being sorted and cleaned of buttons, rubber, metals, etc., were reduced to pulp by washing in water and then setting the mass aside in closed vessels for many days in order that they might undergo fermentation and reach the

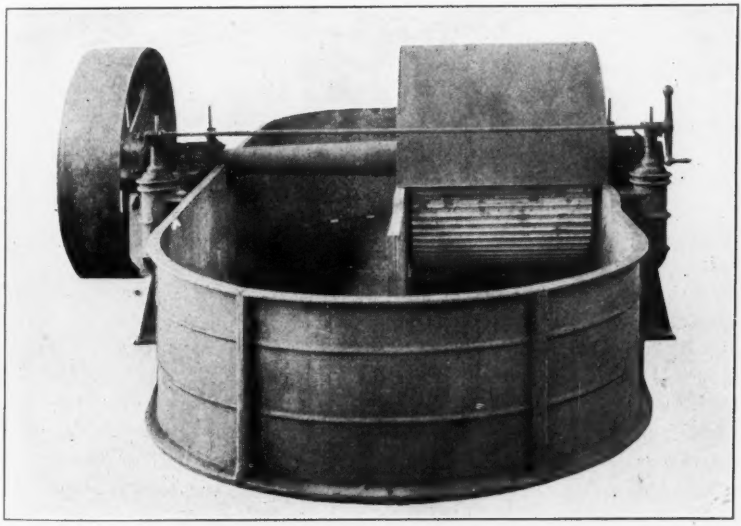

FIGURE 6.—THE HOLLANDER TYPE OF BEATER

desired pasty stage to enable the vat men to dip the pulp into molds, shake out the water to form sheets, and hang them up for drying. To shorten the time, stamp mills similar to those used in powdering ores were introduced but they were likewise slow and tedious. The first important invention was the Hollander or beating engine (Figure 6) which Sindall says (*11*) was in extensive use in Saardam, Holland, in 1697. In this machine, which in an improved form is still in general use, the rags were macerated into pulp by means of a revolving cylinder containing metal knives or blades which rotated in close proximity to similar knives mounted upright in a stationary bed plate. By the action of this revolving cylinder the rags were drawn between the knives, cut, and combed out into the

individual fibers, thus resulting in a mass of straightened fibers suspended in water. A mid rib in the center divided the beater into two channels through which the pulp coursed in continuous beating until reduced to the proper consistency.

With this machine, pulp could be produced faster than it could be made into sheets by hand. A machine was needed to make continuous sheets as well and such a machine was invented in 1799 by Nicolas Louis Robert, a workman in a paper mill in France. For financial reasons the development of this machine was transferred to Henry and Sealy Fourdrinier, wealthy stationers and paper manufacturers of London, England. After spending a fortune in experiments with this machine, its successful operation was finally secured and revolutionized paper making throughout the world. It usually required three months from the time of receiving the rags before the paper made from them could be delivered. By the use of the Fourdrinier machine (Figure 7) the paper could be delivered the day after the rags were received.

The operation of the Fourdrinier machine is as follows: the pulp after being screened is fed upon an endless belt of wire cloth of 60 to 100 mesh, moving over small rolls under which is a suction box or "saveall" into which the water and very fine fibers drain and are rinsed in subsequent operations. Endless rubber straps, known as deckel strips, confine the pulp on the wire cloth to the width desired. The wire cloth is subjected to both lateral and forward motion to assist in the interweaving of the fibers. The wire finally turns downward over the "couch roll" where by means of pressure of a suspended roll or by a vacuum couch roll the fiber is consolidated into a sheet and caught on an endless woolen blanket or "felt" and passed through a succession of polished brass or bronze rolls for the removal of water. After leaving the felt the newly formed sheet of paper is passed on a cotton blanket through a series of steam-heated cylinders for drying and finally the web of paper is passed through a stack of smooth, chilled iron rolls, the calenders, to smooth the paper by means of weight and pressure.

The Introduction of New Processes in Paper Making

Prior to 50 years ago, the raw material for paper consisted almost entirely of rags and the trade and commerce of nations listed the imports and exports of baled rags as important items. From time to time other fibrous vegetable materials were suggested and the patent literature is crowded with descriptions of high quality paper made from materials other than rags. Nevertheless, aside from straw, no considerable success was obtained, and Munsell (*5*) stated that:

> Although a French paper maker claimed to have obviated, by the aid of chemistry, all difficulties in the use of straw, and the experiments of Mr. Beardslee, of Albany,

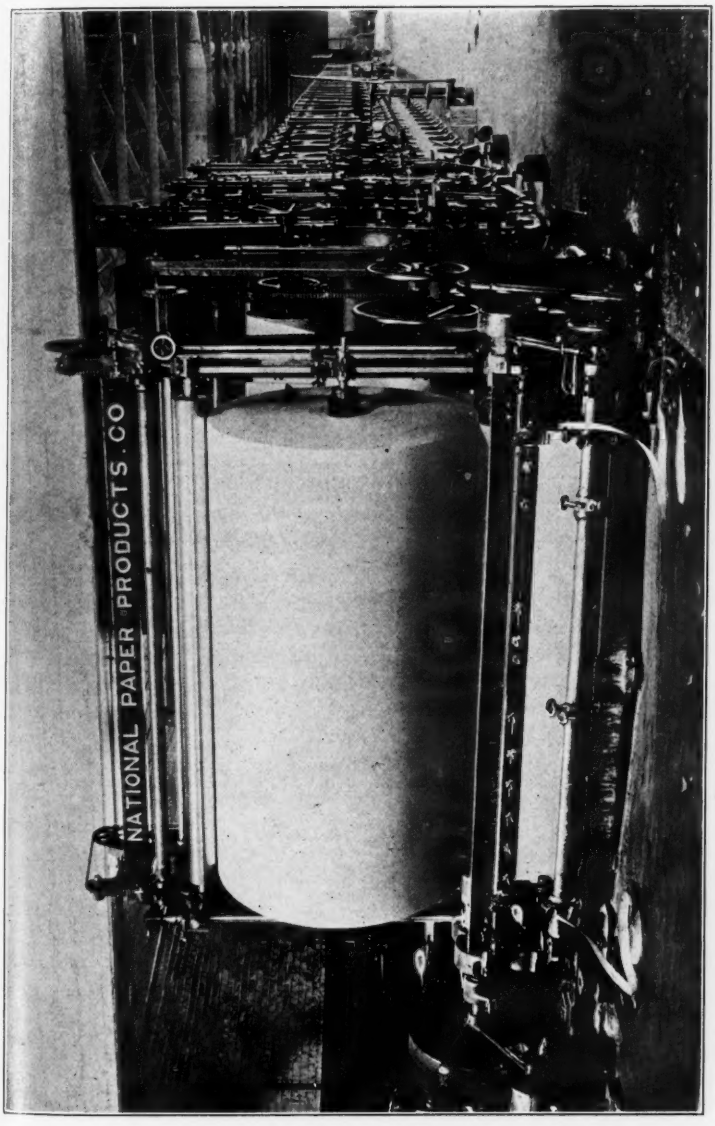

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FIGURE 7.—THE MODERN PAPER MACHINE

were so far successful a few years since as to lead many to hope for an economical mode of converting the forests into paper to supply the all devouring maw of the press, yet it is still thought that we shall never find anything to answer the purpose so well as linen and cotton rags.

Experiments conducted by Hugh Burgess in England had, however, as early as 1851 been successful in making pulp by boiling wood in caustic alkali with the aid of chlorine or hypochlorites, and under Burgess' directions mills were established in America where this process, using chiefly poplar wood, in the course of some forty years developed into one of the minor sources of paper-making material known as soda pulp.

Shortly after the close of the Civil War, Benjamin C. Tilghman experimented with a solution of sulfurous acid to dissolve the intercellular matter of wood and a mill was built in Manayunk near Philadelphia, but it did not prove a commercial success. The Swedish chemist, C. D. Ekman, in 1876 published a small booklet describing the pulp made by him in a mill at Bergvik, Sweden, where he cooked wood in rotating digesters in a solution of magnesium bisulfite, $Mg(HSO_3)_2$. This process was brought to America by Charles S. Wheelwright and developed in the plant of the Richmond Paper Company in Rhode Island, but the process likewise was not a financial success. About the same time, the German chemist, A. Mitscherlich, was developing a sulfite process in which the wood was cooked at lower temperature and pressures than in the original Tilghman process. The American rights to his patents were bought by August Thilmany and the first Mitscherlich mill in the United States was erected at Alpena, Michigan. At first the cooking in this process was continued from sixty to seventy-two hours but eventually this was reduced to sixteen hours. In Austria, the sulfite process was developed by Eugene Ritter and Carl Kellner who succeeded in reducing the time of cooking considerably. The Ritter-Kellner process was first used in a plant built at Merriton, Ontario, in 1885.

While the making of sulfite pulp was in course of development, the grinding of wood by mechanical means was also undergoing development. It is said to have been first suggested by Friedrich Gottlieb Keller from his observations that a wasp's nest was made up of paper of matted fibers of wood, and that at his suggestion Henry Voelter, a practical machinist and paper maker, constructed a machine for grinding wood into pulp. Two of these machines were brought to America by Albrecht Pagenstecher and installed at Curtisville, Massachusetts, in 1867. The pulp from these grinders was shipped to the consumers in barrels and although used only as a filler at first its use gradually became extensive.

The fourth and last pulp-making process is known as the sulfate or kraft process. It originated from a desire to find a cheaper source of alkali than soda ash by the use of salt cake (sodium sulfate), which was a waste

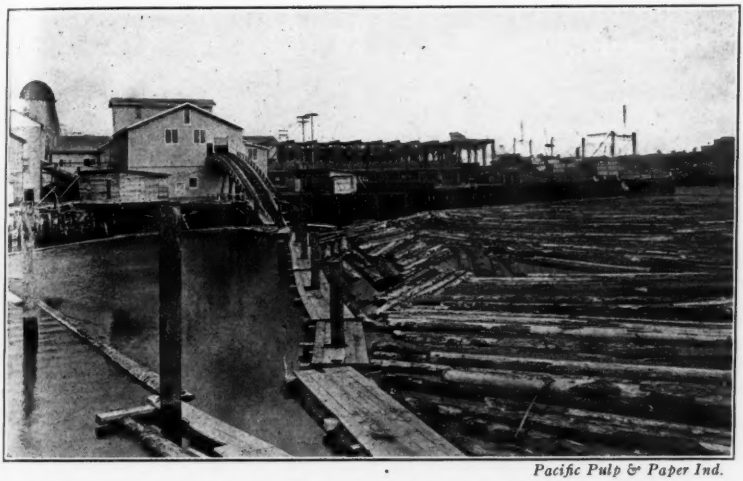

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FIGURE 8.—HEMLOCK SAWMILL WASTE NOW GOES TO AN ADJACENT PULP MILL TO BE MADE INTO PAPER

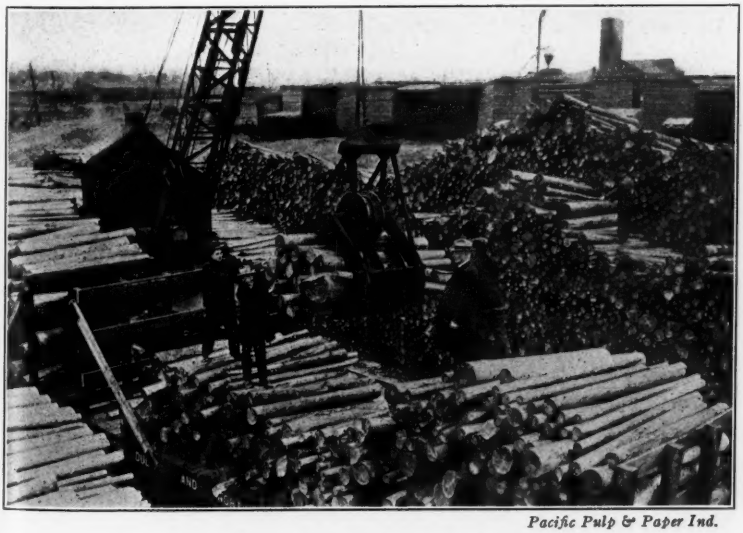

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FIGURE 9.—PULPWOOD STOCK IN MINNESOTA

FIGURE 10.—QUARRY OF SANDSTONE

product of chemical works. The process was established in Danzig in 1884 by C. F. Dahl and in 1907 it was used in a mill in Quebec.

Manufacture of Mechanical Pulp

In the manufacture of mechanical pulp, coniferous or soft woods are mostly used, and of these spruce is the most important, constituting three-fourths of the raw material. Hemlock, balsam fir, and jack pine

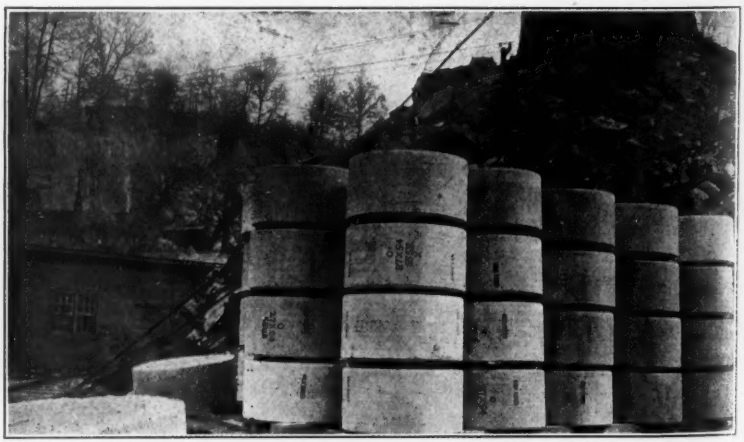

FIGURE 11.—PULPSTONE PREPARED FOR THE GRINDER

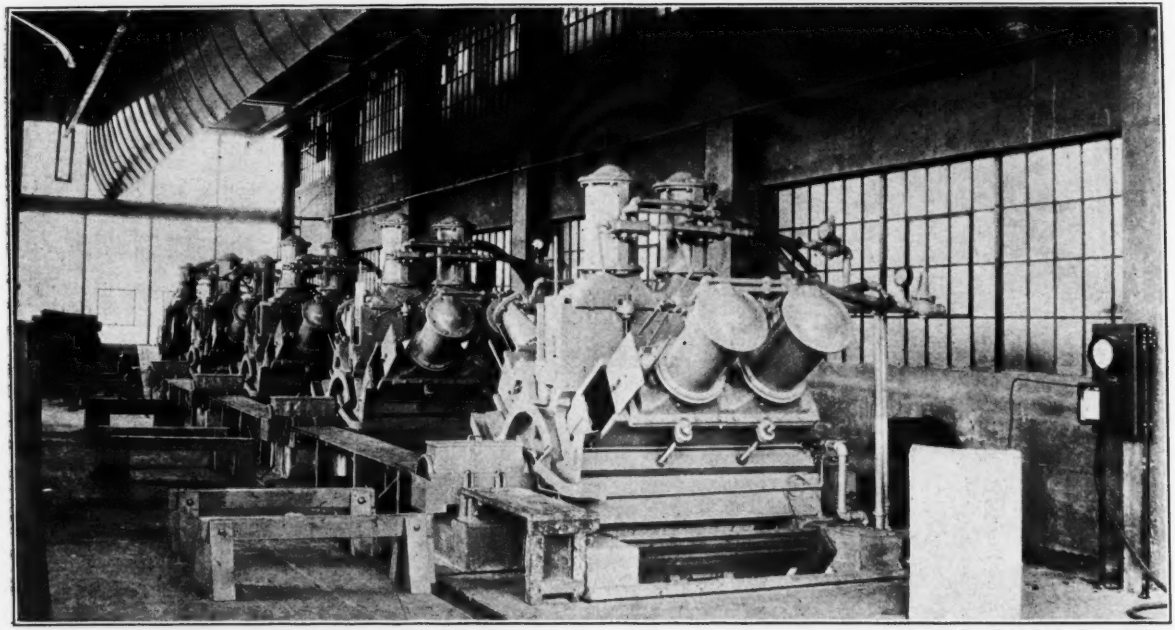

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FIGURE 12.—A BATTERY OF ELECTRICALLY DRIVEN 3-POCKET GRINDERS FOR MECHANICAL PULP

are also suitable. Of the hard woods sometimes used, poplar is the chief. (Figures 8 and 9.)

For grinding wood into pulp natural sandstone or grindstones (Figure 10 and 11) are used. These are mounted on a rotating steel shaft and the wood is placed in pockets so that the wood cut in 24-inch lengths lies sidewise against the 27-inch face of the stone. Grindstones are usually 54 inches with faces 27, 36, and 54 inches to grind wood 24, 32, and 48 inches long, respectively.

The wood is prepared for grinding by first going to the "barking" room where it is caused to revolve against a circular iron disk enclosed in a strong disk. Knives project from the disk which cut or shave off the bark. This process of bark removal or "rossing" also removes a portion of the wood (from 10 to 20 per cent). To lessen this loss rotary drums made of angle irons and revolving in a tank of water are sometimes employed. The wood continuously enters the drum at one end and is discharged clean at the other end.

This cleaned wood is placed in the pockets of the grinder (Figure 12), with the grain parallel to the face of the stone, and held against it by a pressure of 25 to 32 pounds to the square inch. As the grindstone revolves at a speed of 220–250 revolutions per minute the fiber is torn away by attrition applied perpendicularly to the longitudinal direction of the grain. The grinding action produces heat which may be carried away by addition of a large quantity of water in the case of "cold ground" pulp or with the minimum quantity for "hot ground" pulp.

The pulp is carried away from the stone and is passed over screens which allow the fine pulp to pass but retain the slivers, knots, and coarser bundles of fibers. From the screens the pulp goes to the wet machine, where it is put into a convenient form for shipment to the paper mill.

The wet machine consists of a large tank in which rotates a hollow drum covered with wire gauze. The pulp fastens itself to the wire gauze of the revolving drum while the water passes through the gauze and is drained away. Then the sheet of pulp on the drum is picked up by a felt and passed between rollers which press out more of the water. It is finally wound on a large wooden cylinder, removed at intervals, folded into laps of convenient size and stacked, or it may be made into bales for shipment. In this condition it generally contains 50 per cent air-dried pulp and 50 per cent water, air-dry pulp conventionally containing 10 per cent moisture, which is the amount absolutely dry pulp will absorb from the atmosphere.

Mechanical or ground wood pulp is used in the production of newsprint, wall paper, wall board, container board, cheap book paper, and manila paper.

Manufacture of Chemical Pulp

The distinction between mechanical and chemical pulp is based on the manner of isolating the fibers of the wood. In mechanical pulp the fibers

are separated from each other by the physical action of the grindstone. Its composition is therefore unchanged from what it is in the wood. In chemical pulp the binding material, lignin, naturally present in wood is dissolved, enabling the fibers of nearly pure cellulose to fall apart and be separated from each other. Chemical pulp is made by three processes, known as sulfite, soda, and sulfate pulp, respectively.

Sulfite Pulp

Sulfite pulp is made by the action of sulfurous acid contained in solutions of calcium bisulfite. Under proper conditions of heat and pressure, the lignin of the wood goes into solution and the resulting fibers of cellulose constitute sulfite pulp. The steps in this process are the preparation of the cooking liquor, the chipping of the wood, digestion with chemicals, and refining of the pulp.

In most plants sulfur is burned to sulfur dioxide in a rotary or shelf burner; the gas is washed with hot water to remove dust and dirt, then cooled and led into towers filled with limestone over which cold water is trickling. In some cases the sulfur dioxide is led into milk of lime solutions. In either case, the product is a solution containing a total content of sulfur dioxide ranging from 2.8 to 5.5 per cent of which 70 to 75 per cent is free sulfurous acid (H_2SO_3) and 25 to 30 per cent combined as bisulfite, $Ca(HSO_3)_2$.

Instead of grinding the wood it is chipped into pieces varying in size from $^5/_8$ to $1^1/_2$ inches by means of a cast steel disk 84 inches in diameter. Two or three knives arranged radially on the surface of the disk are the cutting instruments. The wood is fed into a spout usually inclined against the disk. The chipper is operated at a speed of 200 revolutions per minute. The chips are next passed over rotary and flat oscillating screens to remove knots, splinters, and sawdust, and stored in bins from which they are fed into the digesters.

Sulfite digesters are of several types; stationary horizontal, rotary, and stationary vertical, the last being the most common type. They are 14 to 18 feet in diameter and 38 to 40 feet in height tapering at both the bottom and top to a cone. They are of steel construction with an acid-resisting lining, with all fittings of bronze or hard lead.

The manner of cooking varies greatly in different plants. After the chips are fed into the digester through a manhole and the liquor added, it is tightly closed and steam admitted directly to the wood through perforated coils in the bottom. The pressure due to steam and gas (from sulfite solution) rises rapidly and in order to secure increase in temperature it must be relieved at intervals through outlet pipes at the top into an acid-reclaiming system. From 8 to 11 hours is required to complete the digestion, the maximum temperature reached in the shorter cooks being

160°C. while in the slower cooks the temperature is usually kept below 140°C. The completion of the cook is ascertained by analysis of the liquor, a content of 0.2 to 0.3 per cent SO_2 denoting completion, or the cooking progress may be watched by comparing the color of the liquor with a standard color scale prepared for that purpose.

The digester is emptied by blowing the chips through a blowout pipe at the bottom under its own pressure into a blowpit where the chips disintegrate, the liquor drains off into a sewer and the pulpy mass is washed with water. The pulp suspended in water is now pumped out of the pit and passed over rifflers, which are troughs containing 5-inch boards nailed at right angles to the bottom, these serving to catch the coarser particles, knots, sand, etc. It is further screened over flat shaking screens or by rotating screens and is then ready for making into sheets which pass through hollow, steam-heated rolls, and are finally made into bales. Recent methods of drying pulp utilize the Kamyr presses (Figure 13) which remove 50 per cent of the moisture by pressure. The sheet in some cases is then shredded and steam-dried and baled. The chemistry of the sulfite process is involved in the reactions of the components of wood. According to Klason (*3*) bone-dry spruce consists of the following:

Components	*Per cent*
Cellulose	53.0
Hemicelluloses	15.0
Lignin	30.0
Fats, resins, proteins	2.0

Of these constituents cellulose belongs to the group of organic compounds known as carbohydrates with a formula $(C_6H_{16}O_5)_n$, the value of n being unknown. Although resistant to the action of chemicals, in a general way, under severe conditions it may be hydrolyzed by acids and alkalies into soluble substances and thus diminish the yield of pulp obtained. The hemicelluloses are polysaccharides which, although insoluble in water, become soluble in alkalies and are converted into simpler sugars by heating with dilute acids. Fats and resins constitute the so-called pitch of wood which causes much trouble in pulp-making due to insolubility in acids. Lignin is the chief component with which all pulp-making processes must contend. Its chemical composition is not known and its uniformity is not constant. It is rather spoken of as a lignin complex in which certain organic groups have been identified. It contains unsaturated ethylene (CH=CH), methoxy (CH_3O), carbonyl (=CO), and hydroxyl (OH) groups. Klason advanced the theory (*9*) that lignin combines with four molecules of SO_2, two of which are present in the form of sulfonic acid; the third is more loosely combined and splits off readily as sulfuric acid on standing in air; and the fourth molecule is so weakly combined that it can be titrated with iodine.

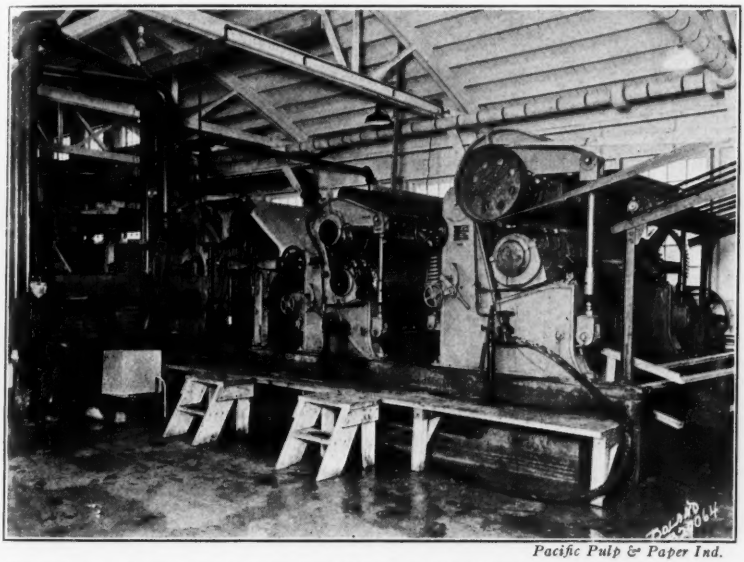

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FIGURE 13.—KAMYR PRESS REMOVES MOISTURE FROM PULP TO ABOUT 50 PER CENT BY MECHANICAL MEANS ONLY

In accordance with this view the cooking process consists of the formation of a soluble calcium salt of lignin sulfonic acid together with dissolved sugars with which the lignin was originally in combination. It explains the dark resinous nature of pulp cooked in a deficiency of lime as well as the necessity of having a sufficiently high temperature to favor the reactions.

From this discussion it is obvious that the yield of pulp is approximately only 50 per cent of the weight of the bone-dry wood. It also is explanatory of the difficulties that have arisen in the disposal of the waste sulfite liquor. No feasible method has been found to recover the sulfur or to utilize the organic matter of the waste liquor. In a number of instances the soluble sugars contained in it have been fermented and alcohol produced on a commercial scale, but only to a limited extent for economic reasons. When this waste is discharged into streams, its biologic oxygen demand has in some instances (*12*) caused the destruction of fish life.

Soda Pulp

In the soda process the solvent action of an alkaline solution is used to isolate the fibers of cellulose from wood. Caustic soda is used as the chemical agent. The process takes place under pressure and at high

temperature. Wood chips are prepared as before and charged into steel digesters which require no lining but are covered on the outside with a jacket of heat-insulating material. The digester is heated by the introduction of steam directly to the lower part of the digester or by means of an injector situated under a perforated false bottom and with a pipe leading to the top of the digester. The velocity of the steam keeps the liquor circulating. Pumps and indirect heating are also sometimes used. During the first two hours the pressure is relieved at intervals to expel the air and favor penetration of the alkali into the chips. The cooking is continued from two to five hours after a pressure of 120 pounds and approximate temperature of 165°C. has been reached. When completed the digester is blown and the pulp screened and washed in the usual way.

The action of alkali on the components of wood is to dissolve the hemicelluloses, resins, fats, and to render the lignin soluble, the name sodium lignate being given to the dissolved lignin. It is evident that the alkaline liquor has a greater range of solvent action than the acid cooking liquor of the sulfite process. This greater activity, however, is also its chief disadvantage for, as Heuser (*2*) has shown, purified soda pulp is itself completely dissolved in a 17 per cent caustic soda solution when heated 6 to 7 hours under a pressure of 10 atmospheres corresponding to 180°C. It is evident therefore that some solution must occur in the milder conditions of the soda cook.

The recovery of alkali from the blowpit liquor constitutes a very important part of the process. The liquor is first evaporated in vacuum triple or quadruple effects from a concentration of $9^1/_2$°Be. to 38°Be., approximately four-fifths of the water being removed and used for washing of pulp. A thick molasses-like liquor results which contains all of the soda and all the intercellular substances dissolved from the wood. This liquor is next fed into a rotary calcining furnace where the remaining water is removed by the heat and the organic matter burned. A red hot cinder known as black ash is discharged from the furnace and is leached under pressure with hot water. The soda is now in the form of sodium carbonate (Na_2CO_3), and any losses in the process are made up at this point by adding commercial soda ash (Na_2CO_3). This solution is then treated in a tank with lime where the process of caustization takes place: $Na_2CO_3 + Ca(OH)_2 \longrightarrow 2\ NaOH + CaCO_3$. The latter known as lime sludge is settled out and in most modern mills is again reburned to lime (CaO).

Sulfate Pulp

In the sulfate process, the dissolving action of the caustic soda is diminished by its dilution with a hydrolyzable sodium compound such as sodium sulfide (Na_2S). According to Klason and Segerfelt (*4*) sodium sulfide does not become caustic until the sulfur has entered into combi-

nation with the lignin and Arrhenius (*1*) has shown that the relative rate of solution of incrustants and cellulose is in favor of the rapid removal of the former and that the cellulose is acted upon less rapidly. The total effect is therefore the production of not only a higher yield of pulp but a pulp of greater strength.

The equipment of the sulfate mill is very similar to that of a soda mill except that special precautions must be taken to produce sodium sulfide. The black ash is therefore placed in a smelting furnace after the sodium losses have been made up by the addition of salt cake (Na_2SO_4) and in the latter undergoes reduction: $Na_2SO_4 + 2C \longrightarrow Na_2S + 2CO_2$. In place of solid black ash fed into the smelting furnace the sirupy liquor from the evaporators containing 70 per cent solids is atomized and burned in the same way as fuel oil. The ash from this burner is removed, dissolved, and causticized in the usual manner to yield the so-called white liquor. It contains 90–100 grams of sodium hydroxide, 25–30 grams of sodium sulfide and 10–20 grams of sodium carbonate per liter. The wood is cooked at a temperature of 150–170°C. for a period of 3 to 6 hours.

Schorger (*10*) states that of the sulfur originally present 52 per cent combines with lignin and 15 per cent is obtained as volatile sulfur compounds, principally mercaptan and dimethyl sulfide which have very objectionable odors and have caused much effort to design odorless sulfate mills. Considerable progress has been made in this direction, several sulfate mills being located in cities without causing undue annoyance.

Bleaching of Pulp

Both sulfite and soda pulps, and to a lesser extent sulfate pulp, are bleached by the action of chlorine. The latter is generally purchased in the form of liquid chlorine transported in tank cars or in large cylinders. The liquid chlorine is run into milk of lime tanks and the heat of reaction used to determine the completion of the reaction: $2Cl_2 + 2Ca(OH)_2 \longrightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O$. The bleaching operation consists in bringing the impurities present in pulp, such as lignin residues, pigments, etc., into intimate contact with a solution of calcium hypochlorite, whereby the latter acts as an oxidizing agent. The oxygen liberated from the calcium hypochlorite either adds itself to the organic molecule or withdraws hydrogen from it, rendering the compound either colorless or soluble.

Bleaching is carried out sometimes in the beaters or in round wooden tanks, with vertical agitators. In the soda mills the consistency is 3 per cent but the more recent practice in sulfite mills is to use bleach engines, in which the consistency of the pulp is much higher than in beaters. The bleach engines usually consist of concrete tanks fitted with vertical worm

drives or screw conveyors circulating pulp of 10 to 20 per cent consistency. Frequently, the bleaching is done in two or more stages with washing between the stages. By using high-density bleaching in the first stage and low-density in the second, it is possible to secure greater strength than by single stage bleaching.

The relative importance of the various kinds of pulp above described can be ascertained by noting the production and importation figures in the United States in 1928 as obtained from governmental and other sources (*8*):

	Production, tons	*Imports, tons*	*Total*
Ground Wood	1,470,000	247,000	1,717,000
Bleached Sulfite	732,869	319,350	1,052,219
Unbleached Sulfite	872,331	649,300	1,521,631
Sulfate	930,800	485,600	1,216,400
Soda	521,000	.....	521,000

Paper Making

The machines used in the making of paper from rags are also used for making paper from wood pulp fibers. Before writing and printing paper can be made from any fibers, however, they must be properly prepared by such preliminary operations as beating, sizing, and filling.

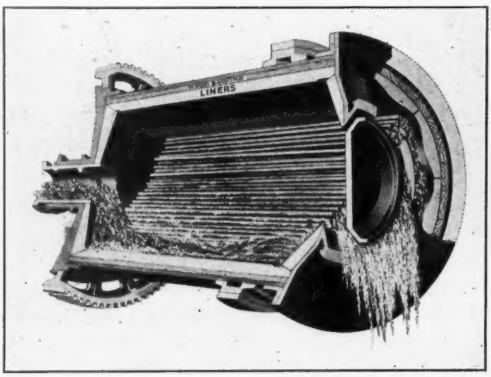

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FIGURE 14.—DIAGRAM SHOWING THE ACTION OF THE ROD MILL IN PULP BEATING

The beating of pulp in a hollander, refining engine (Jordan), ball mill, or rod mill (Figure 14) produces mechanical and chemical results. By the continued action of these machines, fibers are shortened, crushed, frayed, and split, and bundles of fibers are separated and combed out into individual fibers. This permits of more perfect felting or interlacing on the paper machine. But in addition there is another very noticeable result which is known as the chemical change of hydration, in which water is added to the fiber. If beating is carried to an extreme extent, all semblance of fiber structure disappears and a slimy gelatinous mass is formed. In the usual moderate beating some of this colloided or gelatinous matter is formed which on the paper machine produces a compact dense sheet, acting as a binding or cementing material and tending to increase the

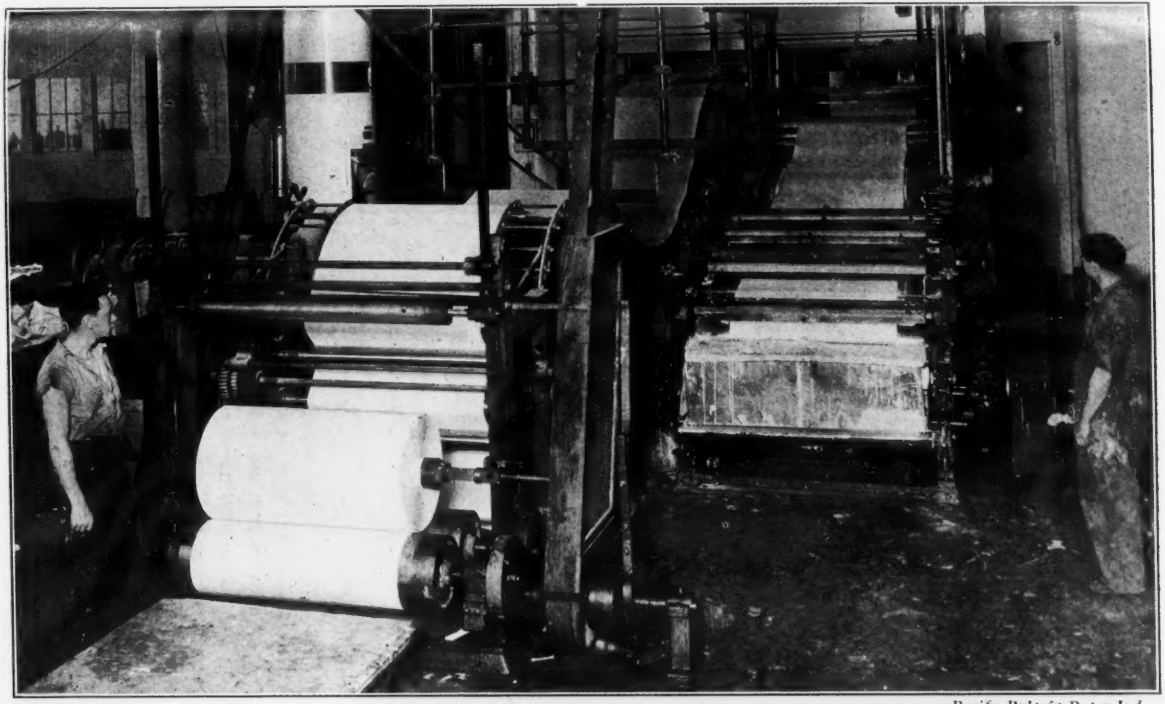

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FIGURE 15.—PAPER COATING MACHINE

In the machine on the right the paper is coming through the solution tank and passing under the brushes on top. On the left the paper is returning and going onto the rolls to be later taken to the calender.

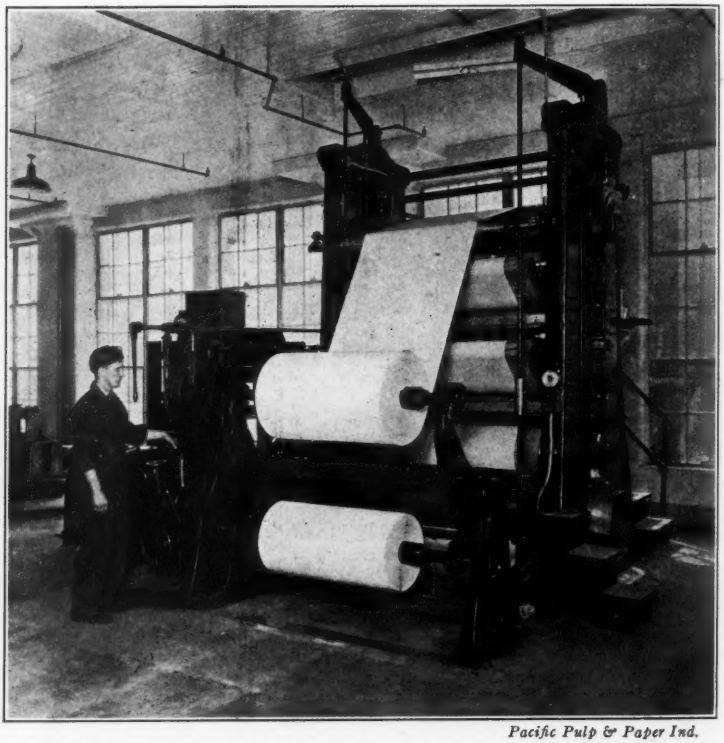

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FIGURE 16.—THE GLOSS AND SMOOTHNESS OF PAPER IS GIVEN TO IT ON THE CALENDER MACHINE

tensile and bursting strengths of the paper. The beating operation may produce free stock from which the water drains quickly or slow stock which, on account of the slimy cementing matter, drains off the water slowly.

In order to make paper water-resistant the fibers are coated with some water-repelling substance known as sizing. Originally paper was sized by dipping the sheet into a thin glue. Now a soap is made by heating rosin (mostly abietic acid) in a solution of soda ash (Na_2CO_3). This soap solution is added to the pulp suspension and later alum or sulfate of aluminum, $Al_2(SO_4)_3$, is added.

The hydrolysis of the sodium resinate gives an alkaline reaction causing the precipitation of free rosin and aluminum hydrate, $Al(OH)_3$. Both of these precipitates are flocculent and curd-like and stick to the fibers. In the subsequent drying and pressing of the sheet they are firmly attached to the fibers and aid in giving ink-resistant qualities to the paper.

To make a sheet of paper sufficiently opaque, destroy its translucency, and prevent the ink from spreading, as in blotting paper, it is necessary to add mineral substances known as fillers which occupy the spaces between the fibers. The most common fillers are china clay and talc.

The color of paper is of much commercial importance, and the selection of the proper dye or dyestuff must take into account its permanency and ease of application. Aniline dyes, pigments, and natural organic dyes are available but at present aniline dyes are generally employed.

The final step in paper making is to transfer the properly beaten pulp with its sizing, fillers, and coloring matter to the paper machine, still known as the Fourdrinier machine, where it is made into a sheet; the water is pressed out; it is dried by steam-heated rolls and passed through heavy rolls or calenders (Figures 15 and 16), which smooth and polish the surfaces into the finish desired.

The production of paper in 1928 in the United States amounts to 1,415,000 tons newsprint, 1,500,000 pounds book paper, and 1,600,000 tons wrapping paper. These classes are subdivided into a large number of grades adapted to various uses.

Problems Still to Be Solved

The story of paper would not be complete without mention of the contributions made by scientists throughout the world. Their researches into the nature of the chemical substances present in the materials of paper making have enabled the industry to attain its present progress. The technical men of the industry by their frankness and eager enthusiasm have coöperated to devise methods of testing and evaluation which have taken their product from a variable and uncertain status to a standard and well-defined commodity. There are still many problems that need study and removal from the empirical treatment now given them. The chemistry of lignin, the bleaching reactions, the colloiding of cellulose, the interplay of mechanical and chemical reactions in the digesters, a knowledge of the substances present in the non-cellulose portion of the pulp wastes and a more intimate acquaintance with cellulose itself are problems which may well challenge the interest of workers in the field of science everywhere.

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(*2*) E. HEUSER, *Paper Trade J.*, **89**, 68 (1929).
(*3*) P. KLASON, *Svensk Pappers-Tid.*, **24**, 7 (1921).
(*4*) KLASON and SEGERFELT, *Papier-Fabr.*, **9**, 1043–9 (1911).
(*5*) MUNSELL, "Chronology of the Origin and Progress of Paper and Paper Making," 82 State St., Albany, N. Y., **1876**, p. 42.
(*6*) *Ibid.*, as (*5*).
(*7*) *Ibid.*, p. 65.

(*8*) *Pacific Pulp and Paper Industry*, **57** (1929).

(*9*) SCHORGER, "Chemistry of Cellulose and Wood," McGraw-Hill Book Co., New York City, p. 73.

(*10*) SCHORGER, *loc. cit.*, p. 410.

(*11*) CROSS, BEVAN, and SINDALL, "Wood Pulp and Its Uses," D. Van Nostrand Co., New York City, p. 16.

(*12*) "Stream Pollution in Wisconsin," *Report of State Board of Health*, **1927.**

(*13*) WEEKS, "History of Paper Manufacture in the United States," Lockwood Trade Journal Co., New York City, p. 107.

WINNERS OF 1929-30 NATIONAL PRIZE ESSAY HIGH-SCHOOL CONTEST

Name and Subject	*High School*
PHILANDER POWERS, "Chemistry and Its Relation to Health and Disease."	Washington High School, 115 East 14th St., Portland, Oregon.
PATRICIA S. MORONEY, "The Relation of Chemistry to the Enrichment of Life."	Manchester High School, South Manchester, Conn.
JOHN STANLEY BANCKER, "The Relation of Chemistry to Forestry."	Tilton School, Tilton, New Hampshire.
ALEX SCHEER, "The Relation of Chemistry to National Defense."	Central Senior High School, Kenosha, Wisconsin.
DORIS ELIZABETH DIERKES, "The Relation of Chemistry to the Home."	The John W. Hallahan Catholic Girls' High School, Philadelphia, Penna.
RUTH SCRIBBINS, "The Relation of Chemistry to the Development of the Building Industry."	New Trier High School, Winnetka, Ill.

Production of Artificial Wool in France. The textile and tinctorial industries are among the most important industries in France, but they are suffering from the general slackness of the wool trade, due partly to the present-day fashions which use less material and partly to the growing use of rayon as a substitute. As artificial wool probably will soon be able to compete successfully with natural wool the situation in the wool trade will take on a more serious aspect. So-called "artificial wool" is a form of non-continuous artificial silk fiber obtained by the "philanization" of cotton—that is the production of wool-like effects by the action upon the fiber at 0 °C. of concentrated nitric acid.

The Saint Gobain Company, one of France's most powerful combines, has floated a new company called the Société des Textiles Nouveaux. The new company is to build and equip works in Northern France to manufacture artificial wool by the Pellerein process. Should satisfactory results be obtained, artificial wool is certain to obtain public favor and it is possible that its use may be even greater than that of rayon.

Generally speaking, the French rayon works give most satisfactory results, according to the 1928 balance sheets. Several new firms have not yet reached the profitable stage, but some of these, however, are building new works and increasing their output. This means that the French output of rayon, which already exceeds the home needs by 50 per cent, will shortly exceed the home wants by 100 per cent. Exportation therefore is a vital necessity.—*Technical Topics*, via *Can. Chem. Met.*

THE 1927 AND 1928 NOBEL CHEMISTRY PRIZE WINNERS, WIELAND AND WINDAUS*,[1]

GULBRAND LUNDE, UNIVERSITY OF OSLO, OSLO, NORWAY

The Nobel Prize is one of the greatest distinctions that can be conferred upon a scientist. The prizes in chemistry for 1927 and 1928 were, as so often in previous years, conferred upon two German investigators, GEHEIMRAT PROF. DR. HEINRICH WIELAND, head of the Chemisches Staatinstitut at Munich, and PROF. DR. ADOLF WINDAUS, head of the Chemical Institute of the University at Göttingen. Wieland was awarded the prize for his work on the bile acids and their constitution, and Windaus for his work on sterols, especially on the constitution of cholesterol.

These two important groups of compounds have engaged the attention of chemists ever since the beginnings of organic chemistry. The determination of their constitution is, however, such a difficult task that only investigators of the caliber of Wieland and Windaus are capable of throwing light upon their complicated internal structure. But even these workers would not have been able to advance our knowledge to the point where today we seemingly stand on the verge of a complete explanation of the constitution of these substances, had it not been for the broad foundation of experimental evidence already laid by a number of distinguished scientists. I may mention here that one of these investigators, Adolph Strecker, whose work has been of fundamental importance for the explanation of the constitution of these substances, was for several years connected with our own university (Oslo).

For many years it was assumed that there might exist a certain relation between cholesterol and the bile acids, but it was not until 1919 that Windaus succeeded in producing positive proof of this relation, through oxidizing a hydrocarbon prepared from cholesterol into the monocarboxylic acid which Wieland had prepared from bile acid.

Once the connection between the two had been established, it was possible to apply directly all the experience gained by Wieland and his fellow-workers in the study of the constitution of the bile acids to cholesterol as well. In the same measure the chemistry of cholesterol has been of significance for the general study of the bile acids.

From this point on, the work of the two investigators is so closely related that it seems natural to view them as one. I shall later summarize our present knowledge of the constitutions of these two substances, which are still far from a complete explanation.

Heinrich Wieland

HEINRICH WIELAND was born in Pforzheim, Baden, in 1877. His father, Dr. Theodor Wieland, was also a chemist. After studying in Munich,

* Translated from the Norwegian by Clinton L. Brooke, University of Minnesota, St. Paul, Minn.

[1] *Tidskrift for Kjemi og Bergvesen*, nr. 1–2, 1929, S. T. nr. 164.

Berlin, and Stuttgart, Heinrich Wieland took his Ph.D. degree at Munich in 1901.

As *privatdozent* at Munich his inaugural dissertation dealt with a systematic and exhaustive study of the reaction between the double carbon linkage and the oxides of nitrogen. At this time, around the turn of the century, organic chemistry had made great progress. The coal-tar products had been studied, and a number of dyes had been prepared from them. Also a number of natural substances had been studied. For example, it had become possible to explain the constitution of the important plant dyes, madder and indigo, and to prepare them synthetically. Especially through the work of the eminent chemist, Adolf von Baeyer,[2] organic chemistry had made great strides.

The examination of a large number of organic compounds had made it more and more essential to study the reactions involved. In this field the work of Johannes Thiele was of fundamental importance, and it is easy to understand that his pupil, the young Wieland, should have participated in this work. In his inaugural dissertation he discusses the fulminic acid synthesis of alcohol and nitric acid, a problem in which Liebig had been interested. The work on fulminic acid was important for the understanding of the mechanism of reaction, which will be discussed later.

During this period in Munich, Wieland carried out his extensive investigations of the hydrazines. This work was especially important since it led to the discovery of the free nitrogenous radicals. The conception of the radical had long played an important rôle in organic chemistry. In 1843, Liebig, in his handbook, defined organic chemistry as the chemistry of compound radicals, and stated as the properties of radicals that they can combine with oxygen and sulfur to form acids and bases, and many with hydrogen to form hydracids. In Liebig's time this was taken to mean that the compound radicals actually existed as separate constituents of the compound. Certain of these radicals existed in the free state, while others did not.

Many chemists attempted to prepare such radicals, but it was not until 1900 that the American investigator, Gomberg, succeeded in preparing a substance, triphenyl-methyl, $(C_6H_5)_3C$, which really was a free radical in the original sense of the word. The corresponding radical with nitrogen as the central atom, diphenyl-nitrogen $(C_6H_5)_2N$, was prepared by Wieland. In solution these free radicals are in equilibrium with the dimeric product formed by their combination. Thus in a solution of triphenyl-methyl an equilibrium is attained between this substance and the dimeric compound hexa-phenyl-ethane:

$$(C_6H_5)_3C—C(C_6H_5)_3 \rightleftharpoons 2(C_6H_5)_3C$$

[2] See J. CHEM. EDUC., 7, 1231–48 (June, 1930).

Wide World Photo

HEINRICH WIELAND

In the same way the diphenyl-nitrogen of Wieland is in equilibrium with tetraphenyl-hydrazine:

$$(C_6H_5)_2N—N(C_6H_5)_2 \rightleftharpoons 2(C_6H_5)_2N$$

Wieland's epoch-making work on the free nitrogenous radicals may, as already stated, be considered in connection with his work on the hydrazines, which is collected in a monograph.

In the preparation of a number of bi-tertiary aromatic hydrazines having the formula $Ar_2N—NAr_2$, where Ar represents the aryl residue, Wieland found that the equation of reaction between the two nitrogen atoms depended to a large extent upon the character of the aromatic substituents. Thus tetra-phenyl-hydrazine was easily split between the two nitrogen atoms, with formation of the radical diphenyl-nitrogen with divalent nitrogen. If substituents such as the phenyl group, C_6H_5, or the nitro group, NO_2, were introduced into the phenyl groups of tetra-phenyl-hydrazine, the dissociation of the hydrazine into free radicals was inhibited. If, on the other hand, substituents such as methyl CH_3, or methoxyl, OCH_3, were introduced into the phenyl group, the dissociation into free radicals was facilitated. In these solutions dissociation into free radicals can often be seen with the naked eye, since the free radicals are colored, while hydrazine is colorless. Wieland has also shown that the same holds true for triphenyl-carbon. Together with K. H. Meyer he showed that triphenyl-methyl and for the rest all triaryl-methyls give a very characteristic band spectrum with a clear, sharply defined band. The triphenyl-methyl ion formed upon the dissociation of the carbinol salts shows, on the contrary, continuous absorption. Thus the radical triphenyl-methyl, $(C_6H_5)_3C$, is entirely different from the ion triphenyl-methyl, $(C_6H_5)_3C^+$.

In the same manner as for hexaphenyl-ethane it has been shown optically that the substituted tetra aryl-hydrazines dissociate into diaryl-nitrogen radicals. Thus the tetra anisyl-hydrazine prepared by Wieland dissociates even in the cold, giving the green dianisyl-nitrogen radical. The dissociation is greatest in tetra-(para-dimethyl-amino)-tetraphenyl-hydrazine, where 10% is dissociated in benzene and 21% in nitrobenzene solution.

In preparing diphenyl-nitrogen oxide, $(C_6H_5)_2N{=}O$, Wieland had found the first organic radical with quadrivalent nitrogen. Diphenyl-nitrogen oxide was prepared by oxidizing diphenyl-hydroxyl-amine with silver oxide in dry ether. The blood-red, glistening color of the solution resembles that of nitrogen dioxide vapor, and also gives a characteristic band spectrum. The color does not become lighter upon cooling, in contrast to the analogous inorganic compound, NO_2. Thus diphenyl-nitrogen oxide exhibits no tendency toward dimerization.

In connection with this important work on the free radicals, Wieland has carried out a number of important researches on the mechanism of

various chemical reactions. For example, he has shown that aside from the cases where free radicals can be demonstrated to exist in solution, or where these radicals can be directly isolated, the intermediate formation of free radicals during the reaction can only seldom be assumed. Wieland has also shown that in reactions such as occur upon the interaction of bromine upon the ethylene double bond, there is first formed a molecular bromine addition product. Such addition products also have been isolated.

Wieland has also made important contributions to the understanding of the mechanism of reaction upon the introduction of the halogen or nitro group into the benzene nucleus. He first succeeded in showing that upon nitrating ethylene with nitro-sulfuric acid in addition to glycol-dinitrate, $O_2NO—CH_2—CH_2—ONO_2$, there was formed also the nitric ester of β-nitro-ethyl alcohol, $O_2NO—CH_2—CH_2—NO_2$. This indicates that the latter compound is formed primarily upon the addition of nitric acid and ethylene, and thus esterified with nitric acid. Wieland succeeded in proving this experimentally. We cannot enter further into the large number of experiments performed by Wieland and his collaborators on this and similar reactions. We must limit ourselves to stating that his studies of the action of nitric acid on the hydrocarbon double bond showed that the products formed were partly nitro-alcohols and derivatives of these, and partly nitro-substituted ethylene hydrocarbons. This work gave experimental evidence that the replacement of a hydrogen atom by an NO_2 group in the aromatic series as well as the aliphatic series takes place through an addition product which generally cannot be determined. In this manner the principal difference in the relation of the aromatic and aliphatic compounds to nitric acid is removed, and only a gradual difference remains. Wieland says of this reaction that the nitro-alcohol formed primarily cannot exist in the benzene nucleus. Because of the loss of energy upon the reconstruction of the aromatic basic system, the double bond opened upon addition cannot hold, and consequently is reformed with separation of water. Later, Wieland showed that the Friedel-Crafts reaction may be explained in the same manner, thus removing one of the properties distinguishing the aromatic character.

In the meantime Wieland had succeeded his teacher Thiele as chief of the organic chemistry division of the University laboratory at Munich. Four years later, in 1917, he was called to the professorship in chemistry at the Institute of Technology at Munich, but in 1921 he left this position to be the successor of Gattermann as chief of the chemical laboratory of the University of Freiburg at Baden, where he worked four years until his recall to Munich in 1925, this time to become chief of the Chemical Institute of the University, a position once held by Justus von Liebig, Adolf von Baeyer, and Richard Willstätter. Nor was there a lack of other distinctions. While at Freiburg he had been made *Dr. med. honoris causa* of the

University of Freiburg and *Dr. Ing. honoris causa* of the Technische Hochschule at Darmstadt. This year (1928) he was elected president of the Deutsche Chemische Gesellschaft.

This brilliant career is easily understood when we consider the large number of important works that have come from his hand. There are the above-named investigations of the mechanism of chemical reactions, of the internal relation between aliphatic and aromatic chemistry, and of the free radicals and their significance for chemical reactions. But besides all these investigations he has during the entire time carried on important studies of natural substances. Without entering into the individual results, I will only mention his studies of the morphine alkaloids, especially important contributions to the study of the constitution of thebain and the compounds of the lobelia plant that influence the respiratory system, and which, like morphine, find application in medicine. Here belong also the investigations of the yellow pigment of the brimstone butterfly (*Gonopteryx rhamni*) and the bitter substances in hops, which finally led to the determination of the constitution of the substances humulon and lupulon. It proved that the bitter substances of hops are a combination of phloroglucin and isoprene, since three or four molecules of isoprene have entered into the phloroglucin molecule, with the formation of humulon and lupulon, respectively. Among his important synthetic studies may be mentioned the complete synthesis of inosite.

The work that more than any other has spread his fame far beyond the narrow confines of chemistry is his studies of the bile acids, so important in physiology, biochemistry, and medicine. These will be discussed later in connection with his studies of cholesterol. Also the study of the poison secreted by the skin of the toad is among Wieland's most important works.

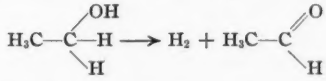
There is, however, another field of investigation in which Wieland's work has been of fundamental importance. It is perhaps his work in this field which has been of the greatest interest in biology and medicine, and which more than any of his other work is known outside the field of chemistry. I refer to Wieland's theory of oxidation. Wieland's conception of respiration and oxidation as a process of dehydrogenation has had a great influence upon the development and explanation of a number of biochemical, biological, and physiological questions. The experimental basis of the dehydrogenation theory is built upon a number of investigations of the reaction mechanism in all conceivable oxidations.

In the living organism energy is produced through oxidation of partly decomposed foodstuffs. It was formerly assumed that the oxygen of the air was carried by the blood to the places where oxidation was to occur, and since molecular oxygen is comparatively sluggish in reaction, it was assumed that it became activated by the ferments of the cells. From this conception developed the theory of slow, free oxidation—the so-called

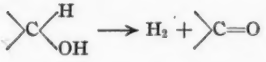
auto-oxidation. It was assumed that the first stage in oxidation consisted in addition of oxygen, with formation of peroxide. In that this theory was applied to biological oxidation, it was assumed that the ferments, the so-called oxidases, primarily bound oxygen as peroxide and thus increased its reactivity.

Wieland's great achievement lies in the fact that he broke completely with these old conceptions, upsetting the entire theory and advancing the idea that in the oxidation process it is not the oxygen but the hydrogen that is activated, and that the oxygen merely serves to absorb or remove the activated hydrogen. Thus oxygen acts only as a hydrogen acceptor. It was this reasoning that showed such great potentialities and led to Wieland's dehydrogenation theory.

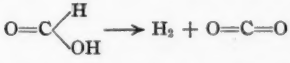
In so far as Wieland's theory was correct, oxidation might proceed without the intervention of oxygen, merely through the elimination of hydrogen. Wieland succeeded in proving the validity of this theory experimentally. To take an example of an oxidation outside the living organism, the transformation of alcohol to aldehyde was investigated:



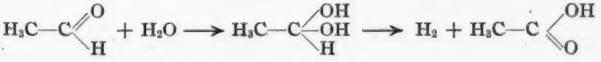
Under careful exclusion of oxygen, alcohol was treated with palladium or platinum as hydrogen acceptor, and it proved that aldehydes were formed. In the same manner Wieland used different substances as hydrogen acceptors, such as quinone or methylene blue, both of which absorb hydrogen more readily than the aldehyde. Here also aldehyde was formed in amounts proportional to the amount of hydrogen acceptor employed. In analogous manner he succeeded in dehydrogenating secondary alcohols into ketones without using oxygen:



In like manner formic acid was dehydrogenated to carbon dioxide:



Also the oxidation of aldehydes to carbonic acids may be explained as dehydrogenation, since it is assumed that water enters into the reaction:



In agreement with this Wieland found that only moist, and not dry, aldehydes were easily oxidized to acids by silver oxide.

Wieland's thorough study of oxidation reactions showed that a number of them actually take place through dehydrogenation.

In biological-chemical processes dehydrogenation plays an even more important rôle. In Wieland's opinion the reason for the rapid march of oxidation and reduction in the cells of the organism is that the enzymes activate the hydrogen of the substratum in such manner that it can combine with oxygen to form water, this being in direct opposition to the earlier theory of the activation of oxygen. Thus oxygen is not the primary oxidizing agent but acts merely as acceptor for the activated hydrogen. The enzymes accelerate the reaction, which otherwise would proceed extremely slowly. In a number of ingeniously devised experiments Wieland has succeeded in demonstrating the correctness of his theory. In a series of biological reactions, oxygen was carefully excluded, and other hydrogen acceptors were employed in its stead: palladium, platinum, quinone, and methylene blue. One of the earliest known biological oxidation processes is the conversion of alcohol to acetic acid under the influence of acetic acid bacteria. Wieland showed that when the ferments acted upon alcohol, acetic acid was formed in amounts proportional to the amount of hydrogen acceptor employed, all oxygen being excluded from the reaction.

Wieland also treated dextrose with dehydrogenating agents under complete exclusion of oxygen, and found that already at body temperature (around 40°C.) abundant quantities of carbon dioxide were formed. It was even possible to effect the combustion of dextrose at a low temperature in the absence of oxygen, using palladium, or palladium and a hydrogen acceptor such as quinone, or organic compounds having a quinoid group. Since the slow combustion of sugar in the interior of the cell is of such great importance, it would be difficult to overestimate the significance of Wieland's researches.

The dehydrogenation theory may likewise be applied to a number of other biological oxidations, and a long series of important experimental researches have been carried out by Wieland and his collaborators, as well as by other investigators who have based their work on Wieland's theory.

Because of the great versatility that characterizes Wieland's work it has not yet been possible to give a complete survey of his activities, which have extended into so many fields of chemistry and biology. His many new views, especially concerning the mechanism of reaction, are set forth in his recent revision of Gattermann's classical text: "*Die Praxis des Organischen Chemikers.*"

It seems almost superfluous to mention that one of the reasons for the many brilliant achievements for which he has received the highest scientific distinction, is his unique talent for organization, which made it possible, especially during the difficult years that followed the War, for him to achieve results of great value with the limited means that stood at his disposal.

The clarity that distinguishes his thinking and mode of expression has made Wieland a brilliant teacher, who in his research work as well as in his personal contacts is strongly bound to his pupils. As one of his many former pupils, I can testify that we wholeheartedly congratulate this great teacher, whom we have learned to value, not only as an investigator and teacher, but also as a man. We could always turn to him confidently, even in purely personal matters, and he always stood ready to advise us or in some other way help us to overcome the difficulties that frequently arose in our studies.

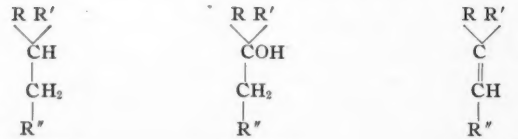
Wieland may be counted among the classical organic chemists. I have heard that he sometimes speaks of "we old organics," and possibly he is right; Wieland belongs in a sense to the old school of organic chemists, but he is much, much more besides. His scientific work is distinguished especially by his great joy in his experiments, the results of which he so well understands how to arrange and survey in broad perspective, with keen criticism and extraordinary clarity. To him might be attributed the same words that Adolf von Baeyer spoke of himself: "I have undertaken my researches not to see if I was right, but to see how the substances would behave."

Adolf Windaus

ADOLF WINDAUS[3] was born in Berlin in 1876. After studying at the Universities of Berlin and Freiburg in Baden, he took his doctorate in 1899 with a work on the digitalis substances, which he had carried out under the direction of Heinrich Kiliani at Freiburg. Four years later, in 1903, he presented his inaugural dissertation as *privatdozent* at Freiburg, with a study of cholesterol, and he has continued his work on this complicated substance during the ensuing years. He has also extended his early work on the digitalis substances, having prepared several of them in the pure state and shown that they all belong to the same class of compounds, namely, the glucosides.

From the leaves of the foxglove, *Digitalis purpurea*, can be isolated two closely related glucosides, digitoxin and gitoxin. Upon hydrolysis they both split off three molecules of digitoxose, $C_6H_{12}O_4$, with formation of digitoxigenin, $C_{24}H_{36}O_4$, and gitoxigenin, $C_{24}H_{36}O_5$. Besides these we have the glucoside of the seeds, *Digitalinum verum*, which upon hydrolysis splits off glucose and digitalose, with formation of a glycogen-like compound (aglycon), $C_{24}H_{36}O_5$, which however at the same time loses two molecules of water with formation of digitaligenin, $C_{24}H_{32}O_3$:

[3] The photograph of Windaus reproduced on page 1773 was obtained for us by one of our foreign editors, PROFESSOR K. FREUDENBERG, University of Heidelberg, Heidelberg, Germany.



Digitoxigenin Gitoxigenin Digitaligenin

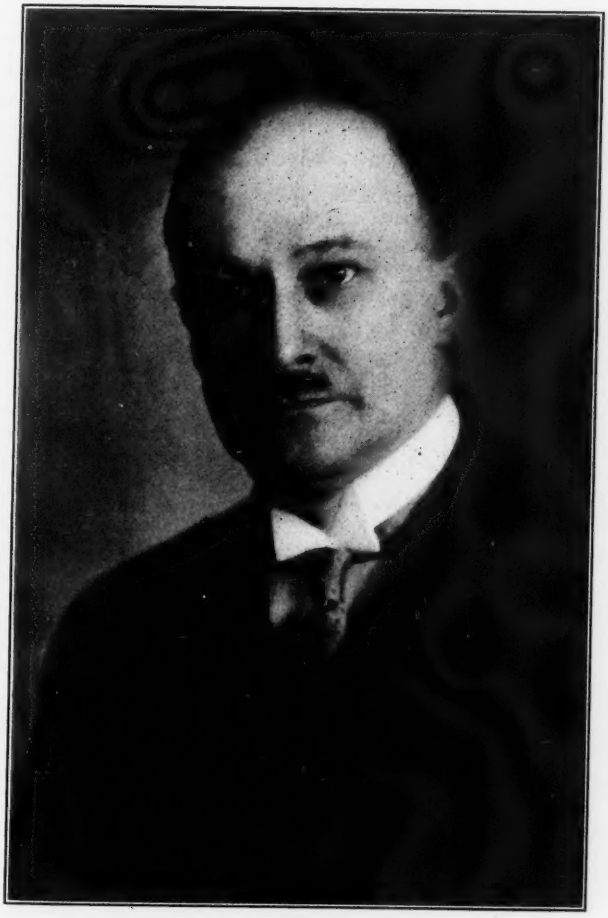
From his researches Windaus concluded that the parent substances of the three heart-glucosides of digitalis thus far prepared in pure state are two unsaturated oxylactones, $C_{24}H_{36}O_4$ and $C_{24}H_{30}O_2$, both of which have four hydrated rings in the molecule. Both can be transformed into two saturated lactones, $C_{24}H_{30}O_2$, which are isomeric, probably stereo-isomeric.

Windaus calls attention to the great similarity between the toad's poison, bufotoxin, the structure of which was explained by Wieland, and the digitalis compounds. Upon hydrolysis, bufotoxin splits off suberyl-arginine, acetic acid, and water, with formation of a mono-oxylactone, $C_{24}H_{30}O_3$, bufotalin, with four double bonds. Digitaligenin, $C_{24}H_{32}O_3$, which is formed upon hydrolysis, with splitting off of sugar and water, and bufotalin can both by means of catalytic reduction be transformed into two isomeric compounds of the formula $C_{24}H_{38}O_3$. Besides the analogy in their pharmacological effect, there is a corresponding analogy in their chemical structure. Both compounds are derived from an unsaturated tetracyclic lactone, $C_{24}H_{36}O_2$, which in the one case has three, in the other five, hydroxyl groups. In plants these hydroxyl groups are bound to sugars, in animals to acids. Windaus points out that we find the same relation between the indoxyl-glucoside of plants and the indoxyl-sulfuric acid (or glucoronic acid) of animals.

Cymarine and strofantine both split off various sugar residues upon hydrolysis, with formation of cymarigenin, which is the same for both. Cymarigenin is closely related to the digitalis genines. It may be regarded as its lower homolog, since it has one less carbon atom, $C_{23}H_{32}O_6$.

Windaus has also made important studies of the constitution of the colchicin of *Colchicum autumnale*. Colchicin has the formula $C_{22}H_{25}O_6N$. In the presence of acid it splits off a molecule of methyl alcohol, and from the colchicin there is formed a complex phenanthrene derivative. In connection with his work on colchicin, Windaus has carried out syntheses of di-hydro-phenanthrene derivatives.

Among his other important works may be cited investigations of imidazol derivatives, especially those closely related to histidine and histamine. Histamine, or imidazol-ethylamine, is especially important on account of its uterus-contracting effect. I should also include the synthesis of fur-ethyl-amine and tetrahydro-furethyl-amine, which likewise is uterus-contracting in a dilution of 1:100,000.



ADOLF WINDAUS

Together with Knoop, Windaus succeeded in showing that when ammoniacal zinc hydroxide acts upon glucose, large amounts of methyl-amidazol are formed. This reaction indicates a probable genetic connection between the hydrocarbons and the important amino acid histidine, and thus also the purines.

In 1906 Windaus was appointed professor at Freiburg, but already in the same year was called to the Kaiser-Wilhelm Institute at Berlin-Dahlem, where he spent several years, until in 1913 he was appointed professor of

chemistry and chief of the Chemical Institute at the University of Innsbrück. In the following year, 1914, he was called to Vienna and since 1915 has been chief of the Chemical Institute at the University of Göttingen, where he succeeded the Nobel Prize winner, Otto Wallach,[4] in the chair once occupied by Friedrich Wöhler.[5]

In all these years Windaus has concentrated his researches above all around the explanation of the constitution of cholesterol. It is impossible here to review all the different stages in the history of this investigation. It has been a long and tortuous way that this investigator, with his untiring energy and immense capacity for work, has been compelled to tread, a way full of obstacles and negative results, but also with many bright places, which have acted as incentives to incessant new experimentation.

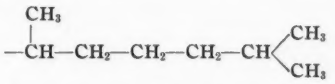
Cholesterol occurs in all parts of the human and animal organism. For the most part it is present only in fractions of a per cent, but occurs in somewhat greater amounts in the brain, the spinal marrow, and the suprarenal glands. Cholesterol is an unsaturated secondary alcohol, $C_{27}H_{46}O$, which is derived from the saturated hydrocarbon cholestane, $C_{27}H_{48}$, and which therefore must contain four rings. Windaus has shown that the double bond may exist in one of these rings, and that the hydroxyl group may exist in another which is condensed with the first. The first of these rings has five carbon atoms; the other six. In the explanation of the constitution there are a number of reactions that have appeared promising, and which are worthy of closer consideration. Upon oxidation the two above-named rings are split each by itself, to dicarboxylic acids, or both together to a tetra-carboxylic acid. Windaus has in this manner studied the pyro-reactions of these carboxylic acids. As is known, upon being heated the di-carboxylic acids with the carboxyl groups in the 1.6 or 1.7 position split off one molecule of carbonic acid and one molecule of water, with formation of a ring ketone, while the 1.4 and 1.5 di-carboxylic acids split off one molecule of water, with formation of an acid anhydride. Windaus has shown that the so-called Blanc reaction also may be directly applied to the hydroaromatic dicarboxylic acids. However it is not only the hydroaromatic polycarboxylic acids that are obtained upon the oxidative decomposition of the cholesterol molecule. In some cases ketones also are formed and since it was important to determine the reaction of these ketones upon heating, Windaus also studied the pyro-reaction of the hydroaromatic γ and δ ketones. Thus it was possible to study the pyro-reactions of the different oxidation products of cholesterol, and draw conclusions as to the number of carbon atoms in the opened rings, and as to the mutual relations of the opened rings. Upon oxidation of the pyro-products thus formed, the new ring ketones could again be opened to di-carboxylic acids, whose pyro-

[4] See J. CHEM. EDUC., **7**, 1224–6 (June, 1930).

[5] *Ibid.*, **5**, 1537–57 (Dec., 1928).

reactions in turn could be studied. In this manner Windaus was able to break down the cholesterol molecule successively, atom by atom, finally arriving at the provisional formula which today is considered the most plausible.

As mentioned in the introduction to this paper, it was especially the transfer of a cholesterol derivative to cholaic acid, the parent substance of the bile acids, that has been of decisive importance for the broader explanation of constitution. Windaus had earlier shown that upon oxidation of cholesterol it was possible to isolate a volatile oxidation product, methyl-isohexyl-ketone. He assumed that the eight carbon atoms in this ketone arise from a side chain:



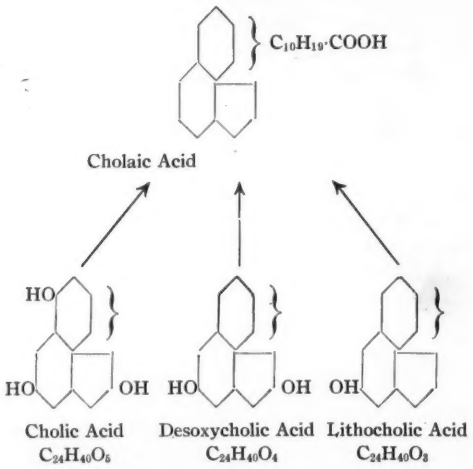
Oxidation by chromic acid anhydride resulted in the splitting off of acetone, while at the same time there was obtained a mono-carboxylic acid, $C_{24}H_{40}O_2$, which was isomeric with cholaic acid; but first in 1919, when Windaus carried out the same reaction with pseudo-cholestane, a hydrocarbon which is isomeric with cholestane (the parent substance of cholesterol) was he successful in isolating cholaic acid. This made it possible for Windaus to transfer all Wieland's experience with the bile acids directly to the investigation of the cholesterol molecule. Later Wieland succeeded in working in the opposite direction, in that he synthesized cholaic acid from pseudo-cholestane, the saturated hydrocarbon which is parent to coprosterol, the isomer of cholesterol.

As already shown by Strecker, the bile acids occur as glycocholic acid and taurocholic acid. These paired bile acids may be split with acids and alkalies into cholic acid and glycocoll, and taurin, respectively. The gross formula of cholic acid, $C_{24}H_{40}O_5$, was stated by Strecker in 1848. Cholic acid contains four condensed, saturated rings with three alcohol groups, one in each of the three rings, and in the fourth ring a side chain whose configuration follows from Windaus' investigation.

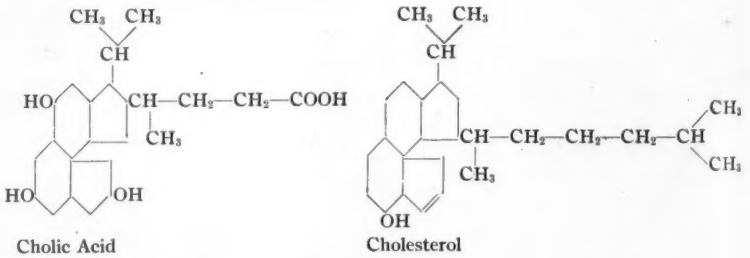
Besides cholic acid we have desoxycholic acid, $C_{24}H_{40}O_4$, with two alcohol groups, and lithocholic acid, $C_{24}H_{40}O_3$, with one alcohol group. Upon splitting off of water and reduction with palladium they are transformed into the same parent substance, cholaic acid (Wieland).

Further, the alcohol groups upon oxidation with chromic acid are transformed into keto-groups, which in turn can be reduced with zinc and hydrochloric acid, by Clemmensen's methods, to cholaic acid.

In his studies of the bile acids Wieland proceeded in the same manner as Windaus. He performed oxidations with strong oxidizing agents and thereby opened rings in the alcohol groups, with formation of dicarboxylic



acids whose pyro-reactions he studied. In this manner the bile acid molecule was successively broken down. Below is given the formula that Wieland's investigations have shown to be the most plausible. There are several desoxycholic acids, of which especially hyo-desoxycholic acid has been thoroughly studied by Windaus.



The work of Windaus that has become best known, and which more than any other has made his name internationally famous, is that connected with the antirachitic vitamin, or Vitamin D.

The discovery of the antirachitic vitamin came about as follows: Professor Hess of New York had found that cholesterol irradiated with ultraviolet light would cure rickets, while cholesterol itself was physiologically inactive. The capacity of cholesterol for activation was especially marked after it had been recrystallized up to 120 times. After this cholesterol seemed identical with the so-called provitamin, the substance which upon irradiation was transformed into Vitamin D.

At this stage of the investigation Hess turned to Windaus, as the foremost specialist in the investigation of cholesterol, with a request for collaboration. They were later joined by Dr. Rosenheim of London. However, in spite of untiring exertions and innumerable experiments, Windaus did not succeed in finding any chemical difference whatever between irradiated and non-irradiated cholesterol. Optical examination of irradiated and non-irradiated samples made by R. Pohl of Göttingen showed, however, a difference in the absorption spectra of such degree that it was concluded that over half of the cholesterol had undergone photochemical change during irradiation, since it was then believed, as previously, that cholesterol was identical with the provitamin. Windaus vigorously opposed this conception, since judging from the results of his investigations, only a few milligrams of the cholesterol could be replaced. The only explanation then was that it was not the cholesterol itself that was photochemically activable, but some impurity which was present in very small amount. Not long afterward, Windaus succeeded in showing that cholesterol which had been subjected to certain chemical treatments did not contain the photochemically activable constituent or provitamin, and soon was able to prepare provitamin-free cholesterol in another manner. This constituted proof that cholesterol is not identical with the provitamin. Shortly afterward Windaus and his co-workers prepared the provitamin by fractional distillation in high vacuum, and by fractional recrystallization from acetic acid. A great number of negative attempts to find the provitamin itself had finally put Windaus on the right track, until he succeeded in showing that the provitamin is identical with ergosterol, a phytosterol which occurs in yeast.

An interesting feature of the discovery of the first vitamin is the intimate collaboration between the medical man, the chemist, and the physicist. It is yet too early to estimate the significance of Windaus' great discovery. His work has been recognized as one of the greatest in modern research; the University of Göttingen has awarded him the degree of *Dr. honoris causa* and the Technische Hochscule of Hannover the degree of *Dr. Ing. honoris causa*. At the great meeting of German chemists at Essen last year (1928), Windaus was awarded the Adolf Baeyer *Denkmünze* (memorial medal). On this occasion Prof. Stock said: "Windaus has shown that the provitamin is not cholesterol, as had been supposed, but ergosterol. Only $^1/_{60}\%$ of this active substance is present in cholesterol; a thousandth of a milligram is sufficient to cure a rachitic rat. The practical significance of this work cannot be estimated today, but we do know that, thanks to Windaus' work, we now possess an unusually active medium in the battle against rickets."

Leisure is time for doing something useful.—BENJAMIN FRANKLIN

MODERN PHYSICS—A SURVEY.* PART I

SAUL DUSHMAN,† GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

Introduction

In order to appreciate the developments in physics which have occurred during the past twenty-five years, it is well to consider briefly the achievements in this science at the end of the nineteenth century.[1]

The first branch of physics to evolve as a well-defined unit was mechanics. The genius of Newton gave it a form which could be developed to even greater perfection by succeeding mathematicians. Thus Lagrange was able to replace Newton's laws by a rather simple differential equation, and finally Hamilton demonstrated that all the laws of dynamics could be deduced from a single principle, the Principle of Least Action, which he expressed in a very elegant mathematical form.

The same methods were now applied to other branches of physics, such as acoustics, hydrodynamics, and optics. In the latter branch, especially, Newton developed the corpuscular theory of light because of the obvious similarity between the laws of geometrical optics and the motion of material particles; while Fermat, in enunciating his principle of least time for the path of a light ray, stated a generalization which is the analog of Hamilton's Principle of Least Action.

It is true that Huyghens favored a wave theory of light propagation, but it was only at the beginning of the nineteenth century that Young's experiments on interference led to the definite overthrow of Newton's theory by Fresnel and others.

The last century saw the birth and growth to full stature of the science of electricity with which the names of Volta, Ampere, Faraday, and Maxwell are connected. By the electro-magnetic theory of Maxwell, optics and electricity became united as the science of waves *par excellence*, and the experimental proof of this point of view by Hertz was all that was needed, apparently, to confirm the whole theory.

It seemed as if the growth of physical science had been completed, and that no new epoch-making discoveries would be made. Yet the very last decade of the century saw the discovery of X-rays by Röntgen, of radioactivity by Mme. Curie, Rutherford, Soddy, and others, and the conception of the electron theory by J. J. Thomson.

Still these new phenomena and the electron theory could have been comprehended in terms of the classical point of view, but other observations

* An address given before the Physical Science Section of the Tenth Ohio State Educational Conference, held in Columbus, April 3–5, 1930; and printed in the *Proceedings;* also in *General Elec. Rev.*, **33**, 328–32 (June, 1930).

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[1] The following paragraphs are based largely on the remarks made by L. de Broglie in the introduction to his famous paper entitled "Researches on the Theory of Quanta," *Annales de Physique*, **3**, 22–128 (1925).

were made at about the same time, which could not be reconciled with any existing theory. In 1900 Lord Kelvin announced that there were apparently two clouds upon the physical horizon. One of these was represented by the experiment of Michelson and Morley, the other involved the failure of classical methods in accounting for the observations on the energy distribution in black-body radiation. As we know now, the first difficulty led to Einstein's Theory of Relativity, while the latter led to Planck's Theory of Quanta.

In the present connection we shall omit any further discussion of the theory of relativity except to point out its profound philosophical significance inasmuch as it puts time and space on an equal basis. They are merely two different attributes. Time is simply a fourth coördinate by which to describe the "world path" of a particle. The conception of absolute motion disappears, and, what is of even greater importance, the old respectable Principle of Causality is discarded, since, according to Einstein's theory, phenomena which are simultaneous for one observer need not be simultaneous for another observer moving with different velocity. We shall be compelled to return to this point once more in a subsequent section.

Origin of the Quantum Theory

Turning now to the theory of energy quanta, we find its inception, as mentioned already, in the observations on black-body radiation. These observations led to the conclusion that not only is matter atomic in its nature, but that radiant energy is emitted or absorbed in units, or quanta, whose magnitude is given by the expression $h\nu$, where ν is the frequency of the radiation and h is a universal constant. The postulation of such a theory meant a complete departure from the highly developed classical concepts. While the latter could always be formulated by differential equations denoting continuity, such a formulation could not be adapted to correlate the observations on black-body radiation, and subsequent discoveries have served only to emphasize the radical difference between the microphysical phenomena to which the quantum theory applies, and the macrophysical, which classical theory "explained" so well.

I have used the word "explained" in quotation marks because it is necessary, before proceeding further, to point out, as was first done by Mach,[2] that theories in physics are not "explanations" of observed phenomena in the philosophical or metaphysical sense of the word. "In other words, theories contain no implicit conclusions regarding some reality *behind* the phenomena. Rather, the object of a physical theory is to develop *a system of conceptions which will enable us to describe the results*

[2] This point is well brought out in a recent address by P. Jordan, *Naturwiss.*, **16**, 765 (1928).

of an experience—a system which shall be as complete as possible and at the same time extremely simple and comprehensive."

Corpuscular Theory of Light

While Planck put forward his quantum hypothesis as a sort of tentative explanation of certain observed phenomena, it remained for Einstein (1905) to suggest a form of quantum theory which emphasized still more the discontinuous nature of energy. Taking as a fundamental axiom that energy is radiated in the form of light corpuscles or quanta of magnitude, $h\nu$, Einstein concluded that in the photoelectric effect the energy represented by this amount must be completely transferred to the electron which is emitted by the action of the light. If W denotes the work required to get the electron through the surface, and V, the maximum kinetic energy (in volts) of the emitted electron, then according to Einstein

$$h\nu = V\epsilon + W$$

where ϵ is the charge on the electron. That is, the kinetic energy of the electron emitted by photoelectric action should be proportional to the frequency and not to the intensity of the incident radiation.

The confirmation of this relation mainly by Millikan[3] and the further observation that the same relation is valid for the inverse photoelectric effect (production of X-rays by electrons incident on a metallic surface) served to strengthen the validity of Einstein's "light-dart" theory. Thus appeared the first sign of dualism in theoretical physics. On the one hand, when measuring wave-lengths of radiation we use the wave theory, but, on the other hand, when we consider the interaction of radiation and matter, we find it more convenient to regard radiant energy as a sort of corpuscular entity, constituted of quanta, "light darts" or *photons*, traveling in straight lines and obeying the laws of geometrical optics.

Classical Theory of Radiation

Now according to the wave theory the simplest mechanism for the production of light is an electrical oscillator, that is, an electrically charged particle oscillating about a mean position of equilibrium with a restoring force which varies with the displacement according to some given law. If the restoring force varies directly as the distance, the displacements can be represented on a time axis as a sinusoidal wave of definite frequency, and, according to classical electromagnetic theory, such an oscillator will emit monochromatic radiation of the *same* frequency as that of the oscillator; the latter is said to be of the linear *harmonic* type. However, *if the restoring force is not directly proportional to the displacement, but*

[3] For an account of this work, see R. A. Millikan, "The Electron," Chicago University, 1917.

varies according to some higher power of the latter, then the oscillator is spoken of as the *anharmonic* type. The displacement, as a function of the time, is then represented by a combination of a sine or cosine wave of the same frequency as in the harmonic type (fundamental frequency) and other sine or cosine waves whose frequencies are integral multiples of the fundamental. The radiation is then no longer monochromatic, but consists of a whole range of frequencies which may be represented by a *series* of values, such as ν, 2ν, 3ν, etc., the whole constituting a range of frequencies which resembles from a formal standpoint the fundamental note and overtones which are emitted by a vibrating string in acoustics. Mathematically, the motion of such an oscillator and the resulting intensity of the electromagnetic radiation as a function of the time may be represented by a Fourier series in which each *harmonic* of the fundamental frequency is represented by the product of a constant (which gives the maximum amplitude of the corresponding radiation) and a cosine or sine function of the particular frequency.

Bohr Theory of Energy Levels

This picture of the origin of radiation, based on the so-called classical theory of electrodynamics, is of particular interest because it was found to lead to conclusions which are in distinct and irreconcilable contradiction with the actual observations on the frequencies of spectral lines emitted by the various elements.

For it had been observed that the lines in the spectrum of an element, such as sodium, could be arranged into a few series in each of which the frequencies of the lines are connected by a rather unexpected but simple relation of the form $\nu = A - B/m^2$, where A and B are constants for any given series, and m *assumes successive integral values for different members of the same series*. In other words, while classical theory led to the expectation that the frequencies of lines would be found to be harmonics of one, or at most a few fundamental frequencies, the spectroscopists found that each line in the spectrum could be represented as a *difference between two terms*. Such an observation obviously cannot be made in general to conform with the representation of the lines by a Fourier series, and hence the mechanism of production of spectral lines cannot be any linear oscillator of the type demanded by classical theory.

It was, however, this very observation that spectral lines may be represented as differences between two terms which was used by Bohr as the most important fact for formulating a completely new theory of the origin of spectral lines. For this purpose, Bohr also incorporated the conclusions reached just previously by Rutherford, Geiger, and Marsden that the atom must be regarded as constituted of a positively charged nucleus and one or more electrons, the number of electrons being equal to the number of

positive units of electricity on the nucleus and each equal to the atomic number, N, which represents the place of the element in the periodic arrangement.

In such an atomic system the attraction of the electrons by the positive nucleus may be balanced in one of two ways; either we can assume stationary electrons and a force of repulsion which just balances the force of attraction when the electrons are at certain distances from the nucleus, or we can assume that, as in the solar system, the force of attraction is balanced by the centrifugal force due to rotation of the electrons in orbits. For many reasons Bohr took the latter view, since the problem could then be treated in the same manner as Newton had originally dealt with the analogous problem in celestial mechanics. On this point of view, the model of the hydrogen atom is that of a single electron rotating about a unit positive charge in an elliptic orbit of definite major axis.

This is the normal hydrogen atom; but in order to account for the observations on line spectra, Bohr found it necessary to introduce two postulates: firstly, that any atomic system is capable of existing in a series of discrete *stationary* states, for each of which the energy is different; and secondly, that *monochromatic radiation is emitted or absorbed whenever the system passes from one state to another*, the frequency of the radiation being given by a relation of the form

$$\nu = E_i/h - E_f/h$$

where E_i and E_f represent the energies in the initial and final states, respectively. It will be recognized that this equation for ν is of the same form as that observed by spectroscopists and that according to Bohr the spectral terms A and B/m^2 are to be interpreted as *energy levels*. In other words, he assumed that these levels or stationary states corresponded, in the case, say, of the hydrogen atom, to different orbits in which the electron may rotate and that the laws governing these orbits are those of ordinary mechanics. Furthermore, in order to define these orbits, Bohr introduced a certain quantum condition, which in the case of a circular orbit may be stated in the form that the angular momentum of the electron in its orbit must always be an integral multiple, n, of the mystic constant, $h/(2\pi)$. The different stationary states thus correspond to different orbits for which the radius increases as n^2 where n is known as the quantum number, while the frequency of rotation decreases with increase in radius.

Of course, according to classical theory, an electron rotating in orbit must radiate energy continuously, which would lead to a continuous decrease in the radius with corresponding increase in frequency or rotation, until finally the electron would fall into the nucleus. But Bohr merely denies the occurrence of such a phenomenon for electronic orbits, and postulates, as mentioned already, that emission (or the inverse process,

absorption) of radiation occurs *only during a transition* of the electron from one orbit to another.

The only defense to be offered for such a set of postulates and assumptions was that they led to remarkable results. Bohr showed that not only could this theory give quantitatively the lines observed in the hydrogen spectrum, but by suitable modification it could be made to account qualitatively for the different series spectra observed for a large number of other elements. As a logical deduction from Bohr's frequency relation it follows that if we have three energy levels, say E_1, E_2, E_3 where

$$\nu_{1,2} = (E_1 - E_2)/h \text{ and } \nu_{2,3} = (E_2 - E_3)/h$$

then it should be observed that

$$\nu_{1,3} = \nu_{1,2} + \nu_{2,3} = (E_1 - E_3)/h$$

The validity of this law, known as the Ritz Combination Principle, had also been observed empirically by spectroscopists, but Bohr first pointed out its significance as a consequence of his theory of energy levels.

The extension of Bohr's ideas by Sommerfeld and others led to a fairly consistent picture of atomic structures in which the more complex atoms could be regarded as being built up from elements of lower atomic number, N, by successive addition of electrons rotating in various elliptical and circular orbits. Also the experiments initiated by Franck and Hertz and continued by a number of American investigators, on the excitation and ionization of atoms by collisions with electrons, and the correlation of the results with certain lines in the spectra of these atoms—all these observations coming as direct consequences of Bohr's theory of energy levels—seemed to serve as a proof of the actual existence of electronic orbits.

Atomic Mechanics on Classical Basis

However, when it came to the application of the laws of Newtonian mechanics to atomic systems containing more than one electron, difficulties of a more and more serious nature began to be encountered. For one thing, ordinary mechanics deals with continuously varying systems and the existence of discrete energy states with quantum transitions presents a phenomenon totally foreign to the whole of classical theory. In the case of an electric oscillator, the frequencies of radiation emitted are simple multiples of a fundamental, and the intensities of the individual monochromatic radiations are proportional to the squares of the amplitudes of the corresponding displacements in the motion of the oscillator. But in atomic systems the frequency of emission of radiation bears no such simple relation to the frequency of rotation of the electron in its orbit, nor, in general, can the intensity of the light emitted be measured by any

properties of a single orbit, since the radiation originates in a transition between two orbits. Under such conditions how can one modify the laws of ordinary mechanics to obtain results in agreement with actual observations?

Bohr had recognized these difficulties early in the development of the theory, but had pointed out that under certain conditions the deductions obtained by classical theory for macroscopic systems must be valid for atomic systems as well. It is well known that the laws of classical electrodynamics apply to radiation of long wave-length; but such radiation is obtained, on the point of view of the new theory, by transitions between orbits of very large radius, where the frequency of rotation is much smaller than for orbits of smaller radius (smaller values of the quantum number, n). For such large orbits, the frequency of the radiation emitted in passing from one orbit to a neighboring one is approximately equal to a simple multiple of the frequency of rotation in either orbit, in accordance with classical theory. Hence the *laws of ordinary mechanics may be applied to orbits of large quantum number* and the deductions thus obtained may then be extrapolated to the case of orbits of small quantum number. This idea, that in the limit the laws of quantum mechanics must approach asymptotically those of ordinary mechanics, was formulated by Bohr as his famous *Correspondence Principle*, and still furnishes the background for even the most recent developments in quantum mechanics. It will be observed that the essential purpose of this principle is to retain in atomic mechanics as much as possible of that classical mechanics which found its most important formulation in the so-called Hamiltonian canonical conditions and the Hamilton-Jacobi partial differential equation.

Difficulties in Applying Classical Mechanics to Atoms

However, while this quantum mechanics, based, as it was, on a hybridization of ordinary mechanics and quantum discontinuities, gave quantitative results in the case of the normal hydrogen atom and ionized helium, it met with real difficulties in the treatment of the *spectrum of neutral helium*, where two electrons revolve around the nucleus. In the case of atoms of higher atomic number, the problem obviously becomes still more complex. Bohr attempted to deal with these atoms as perturbed states of the simple hydrogen-like system. By introducing the notion of penetrating and non-penetrating orbits a certain measure of success was obtained in deriving a general form of expression similar to that which had been found to apply to spectroscopic terms. Also, by assigning to each electron in the atom *four different kinds of quantum numbers*, Sommerfeld, Landé, Pauli, Heisenberg, and others were able to develop semi-empirical formulas for the separation of multiplets and for the effects of magnetic and electric fields on spectral lines. In order to account for

the absence of certain classes of transitions between levels, it was also found necessary to postulate certain *Principles of Selection* regulating the nature of the possible transitions.

A further important generalization was derived by *Pauli* according to which: "There cannot exist in any one atom two electrons having the four quantum numbers respectively the same for both." Utilizing this rule and the different selection principles, Hund was able to deduce a correlation between the arrangement and nature of the electrons in any atom, on the one hand, and the spectroscopic normal term on the other.[4]

As stated already, all this development was based on more or less empirical considerations. All attempts to derive the same results by the methods of Newtonian or classical mechanics proved unsuccessful, and hence the question arose as to whether there is any reason whatever for expecting successful results by this method. Physicists like Bohr, Born, Heisenberg, and others began to consider the whole problem from a more fundamental point of view. As stated by Born,[5] "After all, no other result could be expected, for the validity of the frequency condition is sufficient to show conclusively that in the realm of atomic processes the laws of classical theories (geometry, kinematics or mechanics, electrodynamics) are not right. That in certain simple cases, as for a single electron, they give partially correct results is, in fact, more astonishing than that they fail in the more complicated cases of several electrons. This failure of the theory in the case of interactions among several electrons is evidently connected with the following fact. We know that *electrons react quite unclassically to light waves, because the latter produce quantum jumps*. In a system made up of several electrons, each electron is in the oscillating field due to all other electrons and the periods of these fields are of the same order of magnitude as those of light waves, therefore we have no reason to expect that the electron should react classically to this oscillating field. This point of view gives grounds for understanding why we obtain, by the classical theory, correct results in many cases of the one electron problem."

Failure of Principle of Causality

Also, it is of importance to realize the difficulties involved in the simple model of electronic transitions between levels. In passing, for instance, from a higher to a lower level, the atomic system radiates monochromatic energy. When does this radiation occur? If it occurs during the transition then the electron knows the ultimate level to which it shall pass.

[4] For a detailed account of this work see the writer's paper on "Line Spectra and the Periodic Arrangement of the Elements," *Chemical Reviews*, **5**, 109–71 (1928).

[5] M. BORN, "Problems of Atomic Dynamics." Lectures delivered at M. I. T. in 1926.

This obviously means a *doctrine of determinism* and is therefore utterly absurd. Bohr, Kramers, and Slater suggested in 1925 a theory which would permit the electron to radiate while in its orbit without the occurrence of the transition until a definite amount of energy had been emitted. On this point of view, the law of conservation of energy as applied to atomic system would assume the nature of a statistical principle, that is, one which is true for a large number of transitions, but not necessarily valid for each individual transition. But more recent investigations, especially those connected with the Compton effect (see below), showed the untenability of this point of view. It was demonstrated that the transitions are governed by the existence of certain probabilities for their occurrence. *Hence, it is no longer possible to assume a causal mechanism governing the transitions.*

In fact, it was perceived that the failure to attain successful results by the application of Newtonian mechanics is in reality bound up with the *failure of the so-called Principle of Causality when applied to microphysical phenomena.* As will be shown in a subsequent section, this principle has been found to be just as unnecessary in the new quantum physics as the hypothesis of an ether in the theory of relativity.

Compton Effect

Mention has already been made of the difficulties encountered by physicists owing to the necessity of assuming two different hypotheses for the mechanism by which radiant energy is propagated. Waves or corpuscles? This was the most important question, and numerous attempts were made to settle it. In 1922–23, A. H. Compton discovered a new phenomenon which served to emphasize still more the corpuscular nature of radiation.

When an X-ray impinges on matter, a secondary X-ray is produced of slightly longer wave-length or lower frequency. This is contrary to what would be expected on the basis of classical theory. In order to explain this observation, Compton utilized the theory of light darts or "photons," as we prefer to designate them now.

On this theory, the X-rays consist of streams of energy quanta. While each quantum carries the energy equivalent to $h\nu$, we may also specify each of these "photons" (light units) by the momentum, which, according to the theory of relativity, is equal to $h\nu/c$. When this photon collides with a free or loosely bound electron there is an interchange of both energy and momentum in accordance with the laws of conservation of energy and momentum. Consequently, the photon suffers a recoil in one direction with loss of momentum, while the electron moves off in another direction with added momentum. The collision is, indeed, analogous to that of a golf ball striking a perfectly elastic football. The decrease

in momentum of the scattered X-ray photon corresponds to an increase in wave-length.

Compton found that the actually observed changes in wave-length were in agreement with the theoretical predictions based on the above assumption. A further point that was brought out by subsequent experiments is that this conservation of momentum and energy is not the result of a statistical state of affairs, but must hold valid for every individual collision between a photon and electron.

Here, then, we have a phenomenon which must be recognized as indicating almost conclusively the corpuscular nature of light energy. Yet in these very experiments Compton made use of the wave theory in measuring the wave-length of the secondary radiation.

(To be continued.)

Gigantic Atoms Suggested as Constitution of Space. A new idea of what fills or makes space was recently presented to the National Academy of Sciences by Dr. F. S. C. Northrop, associate professor of philosophy at Yale.

It is "an entity which is atomic and physical in character, and so large in size and fixed in form, as to surround and congest all the microscopic atomic entities of the traditional atomic theory."

Two contradictions exist in current physical theory which can only be met by amendment to present theory, Prof. Northrop declared. A new factor to replace the discarded absolute space is needed, he argued, because atomicity is an inescapable fact and to have atomicity there must be something to refer them to other than the particles themselves.

Modern physics considers that the structure of space is conditioned by matter and that this structure is uniform over large distances. Prof. Northrop found that matter as currently conceived is incapable of producing such uniformity. According to the relativity theory of Einstein, space is the relation between objects, he stated, and the particles of the traditional atomic theory on account of their motion and change cannot be the objects determining space. He has therefore postulated a sort of super-atom filling and creating space.—*Science Service*

Zinc Chloride Used to Remove Vital Organ. A method of removing a diseased organ by chemical rather than surgical means was described by Dr. Charles H. Mayo of Rochester, Minn., at the recent meeting in Atlanta of the Southern Surgical Association. The technical term for the operation is "chemical hysterectomy."

The procedure is particularly valuable in cases when the usual surgical methods of hysterectomy would be too dangerous to undertake because of the presence of serious disease in the heart or kidneys as well as in the organ to be removed. Of course, regular surgical operation is preferable if it can be done.

In the method followed by Dr. Mayo zinc chloride is the chemical used. A few other surgeons have also tried chemical means. Dr. Mayo has followed the procedure in 26 cases in which it was unsafe to operate by one of the usual procedures. He believes that, in its limited field, the method is of value. Carefully done, it has been safe. The patient, unless in bad general condition, can be out of bed in five or six days, he said. —*Science Service*

PIONEERS IN THE COMMERCIAL DEVELOPMENT OF RUBBER

JAMES COOPER LAWRENCE, UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINNESOTA

Rubber was a negligible factor in the existence of the human race until January, 1839. For centuries prior to that time, Indians in the upper Amazon basin occasionally had scraped off from the *Hevea brasiliensis* trees the substance which oozed out when the bark of one of those trees was cut. When heated, particles of this stuff would stick together and then could be made into balls which bounced, or could be smeared upon feet to protect from cuts and bruises.

Christopher Columbus, on his second voyage of discovery in 1493, was entertained by five Indians who played "catch" with a caoutchouc ball. He brought back to Europe with him a sample of the strange new substance and its name, which has been preserved in southern countries as "caoutchouc" and in northern lands as "kautschuk." Obviously, the Indian name was derived from the sound of rubber as it snapped back into its normal dimensions after being stretched.

The British scientist, Priestley, in 1770, accidentally discovered that this rare stuff would rub out the marks made by a lead pencil on a sheet of paper. He put rubber on pencils. And, wherever the English language was spoken, the use devised by Priestley gave the name to the substance. Rubber it was, and rubber it now is in all of its diversified services to man.

In 1823, a Scotch gentleman named Macintosh found that cloth impregnated with rubber was waterproof. He proceeded to originate the raincoat which still is known as a macintosh.

But on extremely warm days the surfaces of Mr. Macintosh's coats turned sticky and distressingly adhesive. On moderately cold days they became stiff as boards. Crude rubber, which became a non-elastic solid at about the temperature which would freeze water and started to change into a viscous fluid when the thermometer crept up above 90°, did not seem to have much commercial value within the range of ordinary temperate zone climatic variations.

Men kept on experimenting with it, nevertheless, and fashioned from it not only waterproof coats, but waterproof shoes, waterproof gloves, and waterproof containers to hold hot water. However, up until 1839, efforts to do more than experiment with the fact that rubber could render fabrics waterproof did not produce satisfactory results.

In January, 1839, Charles Goodyear, "a Yankee enthusiast," discovered the process of "vulcanization." He observed that rubber, to which a small quantity of sulfur had been added, when subjected to a controlled heat for a definite length of time, retained all of the distinctive good features of crude rubber, as he knew them, and in addition was not affected by normal changes in temperature, was more resistant than crude rubber to the deteriorating effect of the atmosphere and more serviceable because of its greater resistance to wear. Goodyear also found that

CHARLES GOODYEAR

vulcanized rubber lost the "tack" characteristic of unvulcanized rubber, *i. e.*, surfaces of vulcanized rubber, pressed together, will not adhere to one another as will surfaces of unvulcanized rubber similarly treated. The obstacles which had baffled Macintosh and his immediate followers had been overcome.

Goodyear obtained a patent on his discovery, and successfully defended that patent in a law suit which enlisted as opposing counsel, Rufus Choate and Daniel Webster.

In following up some of the possible uses of vulcanized rubber, Goodyear also discovered that the rate of vulcanization could be increased by the use in the rubber "mix" of materials such as lime, magnesia, red lead, and litharge, and that when a small quantity of zinc oxide was compounded with rubber and sulfur, the resultant mixture, after being heated for a definite length of time, had a greater resistance to abrasion and a greater tensile strength than a mixture containing only rubber and sulfur.

Goodyear, therefore, founded the rubber industry on five variables: (1) rubber, which could vary with every tree from which it was drawn, with every Indian who prepared it for shipment, with methods of packing, shipment, and storage, and with methods of preliminary handling in a factory; (2) sulfur, the quantity of which, included in any given batch, could range from 1 to 50% of the weight of the rubber in a batch; (3) compounding ingredients and activitating agents of which there are now thousands offering infinite possibilities for varying the character of rubber mixtures; (4) the temperature of vulcanization, which varies from that of superheated steam down to the temperature of the room in which work is carried on; (5) the time of vulcanization, which may be measured in minutes or in hours.

By discovering a few of the possible effective combinations of these variables, men have built up, in ninety years, the rubber industry as it exists today. The effects upon society of the impact of this new basic raw material are only beginning to be seen.

Rubber's part in the general industrial development of the last three-quarters of a century is romantic in its ramifications and impressive in its details. The earnest representations from allied industries at Washington hearings when rubber was one dollar a pound, in 1925 and 1926, rather dramatically brought home to the average citizen the fact that without rubber tires there could have been no development of modern highway transportation, that rubber insulation makes possible the generation and the transmission of electric power, that rubber is essential to aeronautic development, that rubber nipples, rubber hose, rubber thread, rubber belting, rubber caps, rubber heels, rubber gloves, rubber pens, and rubber pavements serve civilized man in such a way as to make crude rubber a commodity of enormous and increasing importance (*1*) (*2*) (*3*).

The orthodox legend of the development of the uses of a new raw material pictures a scientist, with an orderly mind and a keen sense of direction in research, proceeding step by step to solve a clearly visualized problem, much as astronomers sometimes locate a new star in exactly the place where it should be at a given time.

The actual record of scientific progress presents many facts which do not support this legend. Multiplications of the uses of rubber and improvements in methods of rubber goods manufacture have come about in three ways: (1) by the combination of curiosity, observation, and reasoning which sometimes produces planned results; (2) by dogged persistence in seeking results by the method of trial and error; (3) by happy accidents which, when promptly and properly followed up, open up undreamed-of possibilities.

These three ways of making progress in research, to be the most effective, must be combined, and may be illustrated to the layman by the offensive strategy of an American football team. The team, whenever possible, tries to carry out a sequence of carefully planned plays. When its planned attack is thwarted, it doggedly tries other means of attaining the end, in the hope that the method of trial and error may develop something which will work; and when all other efforts seem to be fruitless, the difference between victory and defeat frequently is determined by alertness in taking advantage of a fumble or some other unexpected "break of the game."

Dr. C. O. North, in January, 1929,* summarized the scientific progress of the industry in these words, "In general the advances made in the industry have been the result of resourcefulness and dogged effort. Results had to come, and if they didn't come in one way, well, they came in another."

This revealing statement confirms the explanation of progress which Uncle Remus offered for the dog who escaped from four crocodiles, closing in on him, by running right up a tree. When the little boy said, "But dogs can't climb trees!" Uncle Remus replied, "Honey, this one *had* to."

Prior to Goodyear's discovery, rubber was a curiosity for which there were almost no practical commercial uses. Goodyear founded an industry and carried it to the point where rubber compounding stood as one sort of Black Magic.

Trees and vines with no direct botanical relationship (*hevea, castilloa ficus, funtumia, landolphia*), at widely separated points in the tropics, were found to be rubber yielders. These trees and vines, when cut or macerated, gave up secretions containing, along with varying proportions of resins and other "impurities," pure rubber (caoutchouc) which, by chemical analysis, was shown to have the formula $(C_{10}H_{16})_x$ regardless

* Personal letter—January 9, 1929, to J. C. L.

of the botanical origin of the rubber-containing secretion (the latex). However, factory experience demonstrated that the properties of rubber from *Hevea brasiliensis* trees were different in some vitally important respects from the properties of rubber from *castilloa* trees or *landolphia* vines. Rubber from *Hevea brasiliensis* trees was found to have varying properties which varied with the methods of collecting and coagulating the latex.

Prior to 1905, shop tests of grades of rubber were developed to measure the resin content of samples of commercial rubber. Men trying to see reasons for the observed facts concerning the widely varying qualities of goods made from different kinds of rubber, rather naturally looked for those reasons in the resin-free rubber itself rather than in the varying "impurities" which were found, in some percentage, in all commercial grades of rubber. However, from the standpoint of commercial application, research with rubber which had been freed from readily removable impurities did not bring answers to the fabricator's questions as to why there was such wide variation of some properties in rubbers whose chemical formulas and botanical origins were identical.

To account for varying properties of goods manufactured from different grades of rubber and for the variations in rubbers, as dock observations and shop experience revealed them, the industry evolved a series of fabricators' hypotheses based solely on observation and experience, largely a record of what would work out with reasonable satisfaction in each shop.

All grades of rubber fell into two classifications, according to the ultimate physical properties of the vulcanized stocks in which they were used. A few grades of rubber, after vulcanization under favorable conditions, gave stocks having excellent aging and wearing properties due to their high-tensile strength and to the capacity for elongation and recovery and for resistance to abrasion usually associated with high-tensile strength in rubber compounds. Most grades of rubber, on the other hand, regardless of the compounders' art, gave, after vulcanization, products of low-tensile strength; and, therefore, of low commercial value. The gap between rubbers which could be put into high-tensile stocks and rubbers which could be made into nothing but low-tensile stocks was wide. There was no middle ground. "Up-River Fine" could be made to give a stock with approximately three times the tensile strength of "Islands Coarse."

Men sought for explanations of this vital difference in rainfall and drainage of rubber-growing areas (it was observed that the tree yielding the best rubber had its "head wet and its feet dry"), in the smoke with which rubber latex from the best Amazon areas was evaporated, in the age of trees (rubber from some young cultivated *Hevea brasiliensis* trees gave low-tensile compounds while rubber from some old wild *Hevea brasiliensis* trees in the Amazon area gave high-tensile compounds), and in methods

of gathering and coagulating latex. All of this tended to keep the manufacture of rubber goods in the realm of Black Magic.

Shop formulas were made up solely on the basis of dock classifications of crude rubber with no thought that specifications could be carried to points of greater exactness. If a fabricator's initial experiments with a stock for a specific purpose came out all right with Cameroun rubber, the resultant formula governing future production generally specified "Cameroun rubber." If repeated trials and errors showed that an article could be made best only with Bolivian Up-River Fine Para, the shop formula usually specified "only Bolivian Up-River Fine Para." Alternate substitute formulas frequently were devised, but were regarded with apprehension by the shop superintendent striving to maintain the quality of his products.

"High-tensile" rubber apparently could be secured only from a few areas, principally from the Amazon valley in Brazil. From 1900 to 1905, in a world production of from 50,000 to 60,000 tons per year, less than 25,000 tons per year was rubber which could be made into high-tensile compounds.* Automobile inner tubes, rubber compounds to hold together the plies of tires, rubber gloves, rubber bands, and many other articles generally were made in 1905 from the limited available quantities of "high-tensile" rubbers, such as "Fine Para," Manicoba, Ceara. Accumulated experience within the industry, up to 1905, offered no basis for development or expansion of the rubber business, because accumulated experience had found no way to convert "low-tensile" rubbers into "high-tensile" rubbers; and the supply of "high-tensile" rubbers commercially available was limited and apparently not capable of any appreciable expansion.

Goodyear discovered how some grades of rubber could be made commercially useful. Arthur Hudson Marks, with his associate, George Oenslager, in 1906 and 1907, discovered how rubbers which, in their natural state, would give only "low-tensile" compounds could be made to give "high-tensile" compounds and thus was able to devise ways to make relatively uniform rubber, and to control the industrially important properties of all grades of crude rubber,† replacing Black Magic with science and

* The world consumed, in 1929, approximately 800,000 tons of rubber at prices below the level of profitable production in the Amazon area. It is obvious that an expanding industry would have been greatly restricted and handicapped in its development if compelled to pay the prices to bring out increasing quantities of "high-tensile," "fine" Amazon rubbers.

† Marks' interest in the scientific aspects of rubber manufacture was that of a general devising new and revolutionary means of attack. As general manager of a rubber company, he was interested in winning battles with competitors, not in establishing a personal reputation as a strategist or scientist. Oenslager was an extremely modest scientist working in perfect harmony with a great rubber technologist. With different

ARTHUR HUDSON MARKS

making possible the development to present proportions of the rubber business and of its allied and dependent industries.

In 1898 Marks developed and patented the "alkali" method for reclaiming rubber which now has been standard for thirty years without an essential change. In 1902 he devised a process for the extraction of rubber, on a practical commercial scale, from the Mexican guayule shrub. For five years he shipped guayule from Torreon to Liverpool, prepared it for use in a plant located in that city, and shipped the resultant product back to Akron, Ohio, without having any competitor discover how he could land in Akron rubber (satisfactory for certain purposes) at half the cost of low-grade Para and African rubbers.

The quest for a competitive advantage also led Marks, as early as 1902, to extract a "low-tensile" rubber from "Pontianak." This trade name was applied to the substance (80% resin and 20% rubber) derived from a middle-eastern tree, and shipped from the port of Pontianak, Borneo. He built a plant to prepare this type of rubber for commercial use. The secret process yielded him, by the end of 1905, a supply of usable low-grade rubber at the rate of 30,000 pounds a day, costing less than fifty cents a pound, when Up-River Fine Para rubber was quoted at $1.40 a pound.

The company of which Marks was general manager could not use 30,000 pounds a day of this low-grade rubber. "High-tensile" rubber was very expensive. An enormous advantage over competitors could be

methods of approach to scientific problems, the two men had a common enthusiasm for holding as "company secrets" competitive advantages gained by their scientific skills. Therefore, the story of the fruits of their joint efforts, almost a quarter of a century ago, now is made public for the first time through direct statements to the author by Arthur Hudson Marks and George Oenslager.

established if a way could be found to give to "low-tensile" Pontianak rubber the properties of "high-tensile" Fine Para. The urge of this alluring possibility led to a series of discoveries, second in importance only to the discovery of vulcanization by Goodyear.

Marks reasoned that the difference between Islands Fine and Islands Coarse rubber, or between Fine Para and Pontianak after Pontianak had been deresinated, could not be due to any differences in the pure caoutchouc $(C_{10}H_{16})_x$ content of these rubbers. There seemed to be no essential difference between the approximately pure residuum of a high-tensile rubber, after its "impurities" had been removed in the laboratory, and the residuum from a low-tensile rubber after its "impurities" had been removed in the same way. Furthermore, rubber thus deprived of its "impurities," was found by Marks to be relatively inert when mixed with normal vulcanizing proportions of sulfur and subjected to heat. Other chemists are known to have observed this same fact, but the others did not go beyond this observation.

Marks became convinced, early in 1905, that the reason for the varying properties of crude rubbers could be found not in a study of the pure rubber content, which might be as much as 93% of the mass of the crude rubber as it went into a factory, but could be found in the study of the "impurities" which varied from 7% to 50% of the total bulk of various kinds of crude rubber.

As the next step, Marks took Islands Fine rubber and treated it to separate the pure rubber from the impurities. Islands Coarse rubber was similarly treated. The impurities then were exchanged. The purified rubber which was the residuum of the Islands Fine was mixed with the impurities of the Islands Coarse and the Islands Coarse residuum of purified rubber was mixed with the impurities of the Islands Fine. The original Islands Fine rubber was high-tensile and Islands Coarse rubber was low-tensile. When the impurities were exchanged the properties of the rubbers changed. The Islands Coarse rubber plus the impurities of the Islands Fine rubber became high-tensile.

It then was obvious to Marks that there was present in high-tensile rubbers something which now is known as a "natural catalytic agent" which apparently assisted the association or combination of the pure rubber and sulfur in such a way as to give high-tensile strength to vulcanized products. He reasoned that this natural catalytic agent (although he did not call it that) was not present or was devitalized in the so-called low-tensile rubbers. (We now know that the difference between some of the so-called low-tensile rubbers and the so-called high-tensile rubbers, of identical botanical origin, could be ascribed to the fact that in the method of preparing low-tensile rubbers something took place which soured the latex, and either decomposed the natural catalytic agent or

rendered it inactive.) The natural catalyst was present in the Up-River Fine or the Islands Fine rubber. It was absent in the Islands Coarse when that rubber reached the hands of the rubber manufacturer, notwithstanding the fact that Islands Coarse, Islands Fine, and Up-River Fine all came from the *Hevea brasiliensis* tree in the Amazon area—the difference being only in the methods of preparation. It began to seem reasonable to believe that by adding a natural catalyst or its equivalent to any low-tensile rubber, the low-tensile rubber could be converted into high-tensile rubber.

Marks repeated his experiments until he was thoroughly convinced of the commercial practicability of adding the natural catalytic agent of the Fine Para rubber or a synthesized equivalent to the low-tensile rubbers, thus converting these low-tensile rubbers by this addition into high-tensile rubbers.

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GEORGE OENSLAGER

Looking ahead, his discovery was of importance far beyond the field of wild rubbers. The small quantity of plantation rubber on the market in 1905 was of uneven quality. Much of it was low-tensile rubber. Plantation methods of coagulating latex did not rest upon any comprehension of the possibility of preserving relatively uniform "high-tensile" properties in all plantation yields. If the plantation rubber was to have great commercial value, a way must be found to make plantation rubber uniformly high-tensile. We now know that the reason for low-tensile batches of rubber from *Hevea brasiliensis* trees on plantations was the use of methods of coagulation which rendered ineffective the natural catalyst. Marks, however, undertook to find a way to control, in the factory, this condition, regardless of what variables on the plantations might affect the tensile of rubbers.

Marks, with these and other facts established, asked his Board of Directors to authorize him to equip a research laboratory to employ a skilled chemist to assist in working out commercial applications of the possibilities indicated by his revolutionary discovery. The Board of Directors authorized the necessary expenditure and George Oenslager was employed in May, 1905, to carry on the working out of the problem under Marks' direction.

Marks approached the problem with certain facts as to the possibility

of converting low-grade rubbers into high-grade rubbers clearly established. The next step was to try to find something, readily available in commercially adequate quantities and at commercially acceptable prices, which would raise the tensile of low-grade rubbers in essentially the same way as did the "impurities" from Fine Para. The plan of operation given to Oenslager, therefore, provided that a preliminary search should be made for a substance, or substances, which would act with low-tensile rubbers as would the then unnamed and not any too clearly understood natural catalyst taken from high-tensile rubbers.

It was agreed that a systematic study should be undertaken of the effects of commonly available inorganic compounds of the various groups of elements upon the vulcanization of stocks containing low-grade rubbers. Oenslager restricted the initial field of investigation because of the observed fact that most satisfactory compounding ingredients, then used with rubber to give to rubber compounds properties beyond those possessed by crude rubber, were metallic oxides or hydroxides.

Marks wrote out test formulas stipulating variations in quantities of sulfur and in "curing" time. In accordance with these formulas, Oenslager tested one substance after another, from his own list of preferred possibilities. The first method of testing the vulcanized experimental stocks was simple. Marks or Oenslager would pick up the samples of experimental rubber stock, bend them, and note their recovery from the bending as the first evidence of the desired characteristics.

After some months of progressive experimentation, one sample sheet of the low-tensile stock to which a small quantity of something else had been added came back with a zip when it was bent. That sheet contained red iodide of mercury—considerably less than 1% by weight of the total batch but enough to change amazingly the properties of the low-tensile rubber.

The experimental sheet of rubber had life and authority. Careful tests showed that the conclusions of the first flaming instant of perception were sound. Low-tensile rubber could be made into high-tensile rubber by adding to the low-tensile rubber a very small quantity of a readily available inorganic substance. Science had found the answer to the riddle of the Black Magicians.

Experiments with batches containing red iodide of mercury were quickly repeated. It was found that not only did this substance bring up the tensile of low-grade rubbers, but also it greatly accelerated the "cure." It shortened enormously the time during which it was necessary to heat crude rubber and sulfur mixtures. Goodyear had found that certain activating agents, notably litharge, speeded up vulcanization.* But

* In a letter written February 21, 1930, to J. C. L., Arthur Hudson Marks stated: "As you approach the accelerator idea and comment on the discovery by Goodyear

the red iodide of mercury, added in very small quantities to certain rubber compounds, reduced the curing time from 90 minutes to 5 minutes and gave much stronger stocks with a 5-minute cure than could be obtained in 90 minutes without the red iodide of mercury. The secondary function, which was not the object of the original search, gave the name "accelerators" to the substances assuming this new relationship to rubber.

The work of earlier chemists from Goodyear to Weber had developed experimentally the fact that the rate of vulcanization of so-called "low-grade" rubbers could be accelerated by the use of certain inorganic oxides. Weber, in 1904, reported the use of stearic and oleic acids to shorten the vulcanization time of certain grades of rubber (*4*). The records of the Boston Woven Hose and Rubber Company show that Marks, in 1896 and 1897, used stearic and oleic acids in regular commercial production of bicycle tires and of rubber stamps.

But prior to 1906 "acceleration," through the use of what rubber technologists then called "sulfur-carriers," in no way had been associated with efforts to modify the weaknesses of compounds made with "low-tensile" rubbers, and until Marks established his theory, no one had approached an understanding of why there was a radical difference between the strength of rubber compounds made from "high-grade" rubbers and compounds made from "low-grade" rubbers.

Marks put into commercial production stocks containing mercuric iodide, but goods made from these stocks deteriorated rapidly unless vulcanization was governed with precision.

After the list of common inorganic substances had been checked, Oenslager suggested a repetition of the trials in the organic field. Oenslager

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of certain activating agents, such as lime and litharge, it might not be out of order to have in mind and perhaps incorporate the fact that these early experimenters, prior to 1890, were almost certainly carrying on their experiments with Fine Para. Fine Para contained a natural accelerator which did not embody all of the possibilities that could be gotten from accelerators. Therefore, litharge was active and decreased the time of vulcanization. It is true that these same ingredients which you list did contribute to the usefulness of the so-called low-tensile rubbers [when mixed with them] but the significant point is that they did not bridge the gap between the low-tensile and the high-tensile rubbers. In other words the low-tensile rubbers and the high-tensile rubbers vulcanized without lime, red lead, litharge, and other accelerators prior to those discovered by Oenslager and myself, bore substantially the same relation to each other as they did when used with these accelerators. These early ingredients did not in any way bridge the gap between low- and high-tensile rubbers. The work of Oenslager and myself resulted in ingredients which did bridge that gap. It is clear in my mind that these early discoveries did not at all anticipate the things that Oenslager and I accomplished. The big objective and the most valuable contribution was not in reducing time. It was in making the low-tensile rubbers and later the tremendous crop of cultivated rubber interchangeable with Fine Para and with practically the same characteristics as those of Fine Para."

in the course of this experimentation devised and carried out a trial with aniline oil, thus establishing the first organic "accelerator," and opening the way for the very extensive development of other organic accelerators of vulcanization for use with rubber which, through the years, has followed his first step in this field. Soon afterward, in order to get away from some of the difficulties of handling aniline oil in rubber stocks,* Oenslager developed thiocarbanilide and a number of other materials superior to aniline oil. Today, "organic accelerators," of which there are many, are standard throughout the rubber industry. Experience has shown that good vulcanization can be obtained with lower percentages of sulfur when organic accelerators are used than when inorganic accelerators are used. It is believed that low-sulfur content contributes directly to the best aging of rubber compounds.

Marks studied for months with his patent attorney and with Oenslager the bases for patenting these revolutionary diseoveries. They finally reluctantly made the decision that until some descriptive statement could be evolved completely covering the field and the function of any and all of the possible "tensile-triplers"† and accelerators, the patenting of the accelerators which had been discovered and of the processes which had been developed merely would reveal to competitors these extraordinary possibilities and would stimulate many other laboratories to seek substances, as yet unpatented, which might have the property of converting low-grade rubbers into high-grade rubbers and also would greatly acceler-

* In a letter written April 8, 1930, to J. C. L., George Oenslager said: "The real reasons for getting away from aniline oil were two. Aniline was highly poisonous and dangerous to the factory employees. Also it was a rather weak accelerator. Our real endeavor was to secure a non-poisonous, high-powered accelerator which could be readily handled in the factory without any hazard."

† The manufactured word "tensile-triplers" is used here to make clear the nature of the results obtained from these substances. Prior to Marks' work in this field, it was known that certain substances could be used to accelerate cures. But he was the first, and, for a considerable time, the only manufacturer to arrive at a practical understanding of how and why so-called low-grade rubbers could be made to replace satisfactorily so-called high-grade rubbers in a wide variety of rubber goods.

The uniqueness of Marks' reasoning and of the applications of that reasoning is not clouded by the fairest recognition of the fact that the "accelerating" value of certain substances when mixed with rubber had been noted by earlier chemists. In this field, discovery, with no understanding of what it all was about and no effective commercial use of either new principles or new practice, may well be rated with the supposed Norse discoveries of the North American continent as interesting but not important.

Marks, in 1905, saw the significant facts governing the differences in tensile strength between "low-grade" and "high-grade" rubbers, understood what he was seeing, and applied his understanding. He also saw quickly and made immediate commercial use of the originally unsought-for accelerating properties of the substances whose usefulness was determined by Oenslager's experiments. If Marks and Oenslager had had any rivals in their discoveries, some one else in the period from 1905 to 1912 would have been successful in duplicating the commercial uses of the Diamond Rubber Company's processes.

ate cures. It was decided that the benefits of secrecy were greater than those which might come from a patent full of holes.

All this was in 1906. The secret was so well guarded that, even in 1912, there was not a single accelerated formula in use in the factory of the Diamond Rubber Company's greatest rival, whose buildings stood just across the street from the Diamond Rubber Company's factory.

The experiments worked out by Marks and Oenslager established the existence of a group of commercially available "accelerators" both inorganic and organic which could be added to low-tensile rubbers to give these high-tensile properties and to shorten "curing" times. The first substances found for this purpose, however, were entirely satisfactory only in the presence of certain other compounding ingredients, such as zinc oxide. Ninety per cent of the products of the factory were taken care of in this way; but mixtures of low-tensile rubbers with sulfur only (so-called pure gum stocks), while responding partially to these accelerators in respect to their physical properties, did not resist deterioration satisfactorily.

Therefore, Marks continued his quest for a synthesized catalytic agent which would be the exact equivalent of the natural catalytic agent present in Fine Para Rubber. For this search he engaged David Spence, familiarizing him with what had been done and assigning him the problem of isolating, identifying, and synthesizing the natural catalyst present in Fine Para rubber. The practical success of this quest concluded the pioneering phase of this research.

Marks and Oenslager made the following direct contributions to the rubber business and allied industries: (1) Created a market for plantation rubber by developing methods whereby it could be substituted for Fine Para for nearly all purposes, regardless of the methods of coagulation employed by planters. This made possible the continued development of the rubber-planting industry. Without the supply of rubber from plantations, rubber, automotive, and allied industries would have been seriously hampered in development. (2) Gave to the industry basic scientific methods which still govern the compounding of its materials, especially as affecting strength of compounds and time of vulcanization. (3) By "acceleration" enormously reduced the rubber goods manufacturers' investment in equipment and in employees' time.

However, the discoveries of Marks and his associates were well guarded. Even by other manufacturers, they were not clearly understood until after the World War. Few men outside of the rubber industry were aware of the enormous increase in the use of rubber in the fifteen years following 1906. Within the rubber industry, scores of capable chemists widened into broad highways the trails originally blazed by the pioneers. Rubber consumption was greatly increased by the demand for automobile tires.

But the world did not adequately realize its dependence upon rubber until Winston Churchill, in October, 1922, launched the British Empire upon a program for restricting the production of this commodity.

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(*3*) G. OENSLAGER, "Changes in the Rubber Industry during the Past Fifty Years," *Ind. Eng. Chem.*, **18,** 902 (Sept., 1926); W. C. GEER, "Rubber Chemistry," *Ibid.*, **19,** 1095 (Oct., 1927).

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Waste Movie Developer Is Silver Mine. How one of the large Hollywood motion picture laboratories has turned its tanks of old developing solutions into a silver mine yielding $6000 a month is told by the Bureau of Standards. The emulsion on undeveloped film consists largely of silver, associated with bromine to form silver bromide. When developed, the silver bromide that has been exposed to light changes to metallic silver. In the fixing bath, the unchanged silver bromide is dissolved out, leaving clear spaces where the film was in darkness. Every pound of silver bromide contains over nine ounces of silver. Though miles of film are run through the solutions weekly, and they contain large quantities of silver, they were formerly thrown into the sewer when their power was exhausted. Now, by a simple chemical process, the silver is recovered and sold to the U. S. Mint at San Francisco. Old film is also burned to recover the silver, and sometimes yields as much as $1000 worth of silver a month in addition.—*Science Service*

Odors That Kill Orders. The editor of *Value Mark* tells of a maker of silverware who almost found his way into the bankruptcy courts because the fancy boxes in which his goods were packed were odorous, the glue used being anything but fragrant after the lapse of time in a shop. Before he discovered the trouble his silverware apparently was under a jinx; no self-respecting American housekeeper seemed to want it after she had looked closely into the box (thereby bringing her nose into range of the emanation from the glue).

Leather, cardboard, wrappings, cloth, wood, rubber, linoleum, furs, leather substitutes, paints, adhesives, and a long list of other materials are none the better for queer olfactory properties. The people who manufacture them are the last to take note, on account of the fact that one who lives constantly in any odor loses all sense of it.

There are synthetics for killing or neutralizing many natural odors which are objectionable to the public. The chemist is constantly being called upon to meet such problems, and generally he succeeds.—*Business Chemistry*

SYMPOSIUM ON "THE RELATION OF COTTON TO CHEMISTRY."* INTRODUCTORY REMARKS

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The prevailing and prospective low price of cotton, in contrast with the increased cost of production, makes it extremely important and helpful that there is being held in this chief city of the South a Symposium on "The Relation of Cotton to Chemistry."

For historical background let us go back to the days when the only commercial product of the cotton plant was the lint of the cottonseed. Were this true today the profitable raising of cotton would be absolutely impossible. Fortunately, the chemist saved the day for the cotton planter. For the seed from which the lint has been ginned, at one time thrown away, is approaching nearer and nearer the value of the lint. The steps through which this has been accomplished are: first, the utilization of the oil, which after so many trials and tribulations finally has won its present well-recognized and thoroughly established position as a foodstuff, thanks to the excellent work of our colleague, David Wesson. "Linters," the very short fiber remaining after ginning the textile fiber, found few uses except for low-valued articles, until they became important as a commercial source for the purest type of cellulose found in nature.

The story of the manufacture of linters into rayon, lacquers, celluloid products, synthetic leather, cellophane, etc., reads like a romance. For many years cottonseed hulls have been considered as the dregs of the cotton industry, with practically no commercial value. Yet at this meeting these hulls are emphasized as the raw material for the manufacture of a new commercial sugar, xylose, for whose successful development we are indebted to the chemists of the U. S. Bureau of Standards and the progressive spirit of Theodore Swann.

The "meats" from the cottonseed remaining after the pressing out of most of the oil content were for years used only as a nitrogenous fertilizer, and more recently elevated a step through being used as a cattle-feed. Now, thanks again to David Wesson, there is promise of a far higher utilization, in the form of a protein food, as will be shown by him today.

While the chemist has been busy along these lines, there is a striking

* This symposium was held jointly by the Division of Cellulose Chemistry and the Division of Chemical Education, at the 79th Meeting of the A. C. S., at Atlanta, Georgia, April 9, 1930. The program was as follows:

CHARLES H. HERTY. Introduction.
HARRY LEB. GRAY. "The Constitution and Properties of Cellulose."
CHARLES E. MULLIN. "The Relation of Cotton to Synthetic Fibers."
DAVID WESSON. "The Cotton Crop and Our Food Supply."
M. J. CALLAHAN. "The Relation of Cotton to Lacquer."
R. G. WOODBRIDGE. "The Relation of Cotton to Explosives."

With the exception of Dr. Wesson's paper, of which an abstract only is published, all of these papers are here recorded.

contrast in the lack of activity in two other important lines, at least so far as this country is concerned. The cotton-textile industry, dependent upon the lengthy fiber of the cottonseed, has shown less of the spirit of modern research than almost any other industry. Aside from the removal of the oil coating of this fiber for the manufacture of absorbent cotton, and its treatment with caustic soda under tension in mercerization, no striking advances have been made, and no striking advances may be expected from the small amount of research now in progress.

This cotton fiber constitutes the purest form of cellulose in nature, yet we are still groping almost blindly for knowledge of the composition of the cellulose molecule. Its empirical formula of course we know. Interesting attacks are being made upon this question by Ritter of the U. S. Forest Products Laboratory from the microscopic standpoint, by Sponsler and Dore with the use of X-rays, and by Gray and others through purely chemical studies. But the amount of research devoted to this problem is almost minute when we consider that industries based upon the use of cellulose represent a capitalization of over eight billion dollars.

I repeat, it is fortunate that chemists from all parts of the country are here in the midst of the cotton fields of the South, and it is to be hoped that from this Symposium there will result a stimulation of activity and research in all of the lines above indicated, and if it does there is no question but that this Atlanta meeting of the American Chemical Society will be held as an historical incident in the economic progress of the Southern States.

THE CONSTITUTION AND PROPERTIES OF CELLULOSE*

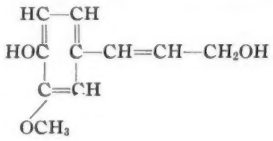
HARRY LEB. GRAY, EASTMAN KODAK COMPANY, ROCHESTER, NEW YORK

The tremendous growth in recent years of the industries using cellulose as a raw material has made it imperative that as full a knowledge as possible of the structure and chemistry of this body be obtained. In the early days of paper and textile manufacture, when "rule of thumb" prevailed and competition was not keen, the incentive to study cellulose was only that of pure research. But, as the artificial silk, film, and lacquer industries, which use cellulose derivatives, grew, it became of the utmost importance on the commercial side to understand the chemistry of this body as fully as possible, that processes might be cheapened and better products made. This has resulted in making the chemistry of cellulose

* Contribution to the symposium on "The Relation of Cotton to Chemistry," held jointly by the Division of Cellulose Chemistry and the Division of Chemical Education, at the 79th Meeting of the American Chemical Society, at Atlanta, Georgia, April 9, 1930.

a very important branch of this subject both from the standpoint of pure research and that of industry.

Cellulose associated more or less with lignin is found in most plants. As to whether the cellulose is actually combined with the lignin (the so-called ligno-cellulose), is loosely held as by secondary valences, or the two are merely associated, is an open question. In attempting to decide this, the means employed are so drastic that one cannot tell whether bonds have been ruptured or not. Lignin is a very complicated body supposed to be four condensed molecules of coniferyl alcohol.[1]



Dr. Ritter[2] of the Forest Products Laboratory has isolated from wood two distinct lignins.[3]

The fibers forming the seed hairs of the cotton plant contain a higher percentage of cellulose than any other known source. The structure of these fibers is very interesting. They grow from the seed and are of varying lengths. When the long fibers have been removed by a process called ginning, shorter fibers are left which are removed by cutting and come into the market as linters. It is this form that is generally used in making the derivatives.

A long fiber under the microscope appears as a flattened tube, twisted in places, with a broad flattened end, where it has been torn from the seed and from this end gradually tapering to a point at the other. Under high power and with polarized light a structure may be seen. Stomata or small pores appear at the edge and running spirally from these are lines. Some believe that the fiber is a single cell, but personally I am inclined to believe that it consists of a number of cells. At various times I have tried to force liquid into the hollow portion by vacuum and by capillary action, but have never been successful. Later I found that de Mosenthal[4] had made the same attempts with the same results.

If a fiber is treated with Schweitzer's reagent—copper hydroxide dissolved in ammonia—the fiber swells, not continuously, but in sections so that the result has the appearance of a string of sausages. As the treatment proceeds the constrictions burst as well as the sausages and the cellulose passes into solution. If a single fiber under these conditions is carefully observed, it will be seen that when a sausage bursts a very thin skin does not dissolve but floats away. This would point to a difference in the outer layer, at least physical if not chemical. In one observation one of the spiral lines broke loose and unwound the length of the fiber.

Balls,[5] by swelling a cotton fiber in alkali and carbon bisulfide, has been able to see the daily growth rings. According to him there are never less than 20 nor more than 25; on the fuzz never less than 16.

I have discussed the structure of the fiber briefly that some of the difficulties in making the derivatives may be better understood.

Cellulose is very resistant chemically. There are no true solvents in the sense that apparently the cellulose cannot be recovered from its solutions in the same condition as before dissolving. When recovered, it is more reactive and changes have taken place, the exact nature of which are unknown. Any attempt to treat cellulose causes some difference. An example is standard cellulose.[6] This is made by extracting Wannamaker Cleveland sliver with alcohol and then ether. It is then boiled with 1% NaOH solution, care being taken to exclude air, till the solution comes free from the yellow color. It is then washed with boiling water until free from alkali, cooled without access to air and then treated with 1% acetic acid, washed, and dried. A 2% solution of the original sliver, the sliver after extraction, and the standard in cuprammonium gave the following viscosities:

Original	178,000 centipoises
After extraction	230,000
Standard	37,700

Ultimate analysis shows pure cellulose to consist of carbon, hydrogen, and oxygen in the ratio of $C_6H_{10}O_5$. The molecular weight has not been determined because it is not volatile and does not form true solutions.† Therefore, at present we will write the formula $(C_6H_{10}O_5)_x$, where x may be one or some other whole number. The empirical formula indicates that cellulose may be a carbohydrate. In 1883 Flechsig[7] claimed that cellulose could be entirely converted into glucose. Ost and Wilkening[8] hydrolyzed cotton with sulfuric acid and obtained an almost theoretical yield of glucose, as estimated polarimetrically and by means of Fehling solution. Subsequently, Willstätter and Zechmeister[9] showed that cellulose was soluble in 41% hydrochloric acid and that such a solution upon standing resulted in the hydrolysis of cellulose to glucose. The polarimeter and Fehling solution both indicated a 95% yield of glucose.

That cellulose is capable of hydrolysis quantitatively to glucose was firmly established through the work of Monier-Williams,[10] who hydrolyzed cellulose with sulfuric acid and actually isolated pure crystalline glucose to the extent of 91%. The work of Irvine and Soutar,[11] done at approximately the same time, confirmed the result. The latter workers subjected

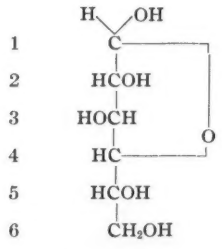
† After this paper was written, A. J. Stamm in a paper given at the Atlanta meeting of the American Chemical Society, April 7–11, 1930, gave the molecular weight as $C_6H_{10}O_5 \times 200$ to 240. These results were obtained by dissolving the cellulose in cuprammonium solvent and using the ultra centrifuge method devised by The Svedberg.

cellulose to acetolysis with sulfuric acid in the presence of acetic anhydride and acetic acid and hydrolyzed the resulting glucose acetate with a methyl alcohol solution of hydrochloric acid, thereby obtaining α-methyl glucoside. This was, of course, readily converted to glucose. The yield obtained in this way was 85%. Subsequently in 1922, Irvine and Hirst,[12] through modification of the acetolysis method and the use of slightly stronger alcoholic HCl, brought the yield of glucose to 95.1% of that demanded by the expression $(C_6H_{10}O_5)_x \longrightarrow C_6H_{12}O_6$.

By this time very strong evidence had been obtained that cellulose is a polysaccharide and that its sole product of ultimate hydrolysis is glucose.

Glucose is an aldohexose and the structural formula was given as

Later it was found that it had characteristics best represented by an oxide ring structure.



The question now arises as to whether the linkage is at the four or five position if we number the carbon atoms from 1 to 6, beginning with the aldehydic carbon. As to the exact location there is still a controversy.

I have discussed glucose that you may understand some of the considerations which must be taken into account in formulating a structure for cellulose.

Cellulose, while ordinarily very resistant chemically, under certain conditions becomes very reactive. It is capable of forming esters and ethers; it is easily oxidized and hydrolyzed; in other words, its reactions parallel very closely those of an alcohol.

In 1832 Braconnot[13] treated cellulose with nitric acid and obtained a product which he called Xyloidine. Pelouze[14] and Dumas investigated this reaction further and Schönbein[15] developed it technically. By treating cellulose with a mixture of nitric and sulfuric acids and water, he obtained a product differing from the original material. It had a very harsh feel, was exceedingly inflammable, and contained nitrogen. This was called nitrocellulose, a misnomer, because subsequent investigation has shown this body to be a true ester, cellulose nitrate. The highest which may be obtained contains about 13.9% nitrogen and corresponds to a trinitrate (theoretical 14.16%). This would indicate that cellulose has three available hydroxyl groups for every C_6 unit. Since the discovery of the nitrate the esters of many of the aliphatic acids and some of the aromatic have been made. But in no case, with one exception, has an ester been obtained higher than the tri. The exception is the tetra acetate obtained by Cross and Bevan.[16] This is open to grave questioning as it was made from cellulose which had been regenerated from viscose and therefore probably very much degraded.

It was discovered that if cellulose is treated with sodium hydroxide and methyl sulfate, an ether is obtained. The ethyl ether has been made and higher ethers have been produced. But here again in no case has an ether been made higher than a tri per C_6 group.

Irvine[17] and his co-workers applied the ether formation to a study of the structure of cellulose. By repeated methylation and subsequent hydrolysis they obtained a practically quantitative yield of crystalline 2,3,6-trimethyl glucose.

Structural formulas for cellulose have been proposed by Tollens,[18] Vignon,[19] Cross and Bevan,[20] Bernadou,[21] Nastyukov,[22] Green,[23] Hess,[24] Hibbert,[25] Schorger,[26] Irvine,[27] Gray,[28] and Oddo.[29]

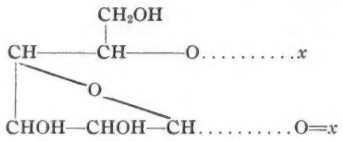
In constructing a formula which correctly expresses the structure of cellulose, the following facts must be taken into consideration:

1. It must yield glucose as the sole ultimate product of hydrolysis.
2. It must have three available hydroxyl groups per C_6 unit.
3. It must yield upon methylation and subsequent hydrolysis, 2,3,6-trimethyl glucose only.

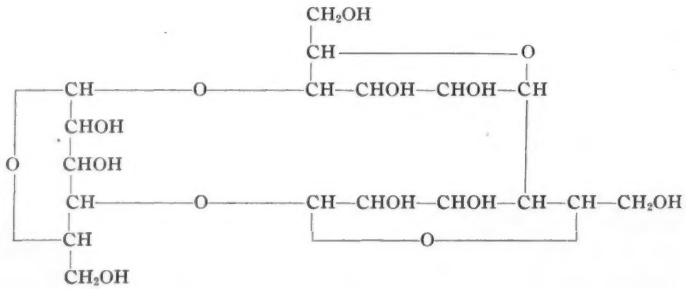
There are other reactions such as the formation of bromomethyl furfural when cellulose is treated with hydrobromic acid in presence of ether or chloroform and the formation of isosaccharinic acid when oxidized cellulose is boiled with milk of lime, but personally I believe these reactions are too complicated to throw much light upon the subject at present. Here I wish to correct an error which has crept into nearly all the literature. Tollens[30,31] first found that oxidized cellulose when boiled with milk of lime gave *isosaccharinic* acid. Through an error, probably of translation, this was given as *isosaccharic* acid. Heuser[32] notes this.

From the known facts we can now see that cellulose is a polysaccharide composed of one or more anhydro glucose units. It now remains to ascertain how the oxygen bridges are connected and the value of x in the empirical formula. Before proceeding, however, I wish to add another factor to this formula. The molecule of cellulose forms aggregates. How, as yet, we do not know. So we may write the formula thus: $(C_6H_{10}O_5)_{xy}$ where x represents the molecular unit and y the aggregate.

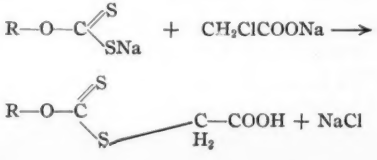
Of the formulas proposed, I shall restrict myself to a discussion of three. Hibbert[25] suggested this formula.



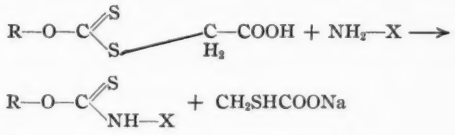
Irvine[27] proposed the following:



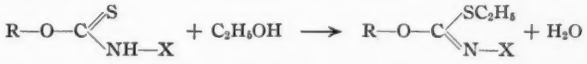
It is in accord with the facts which I have given and gives upon hydrolysis a trisaccharide and a disaccharide, cellobiose, both of which have been isolated. However, chemical evidence has accumulated which indicates that one hydroxyl per C_{24} is different from the other eleven. When viscose is ripened it reaches a certain stage which upon analysis shows one xanthate group per C_{24}. Lilienfeld found that if viscose R—O—C(=S)—SNa is acted upon with the sodium salt of monochloroacetic acid, the following reaction takes place.



If this is then treated with an aromatic amine another change takes place.

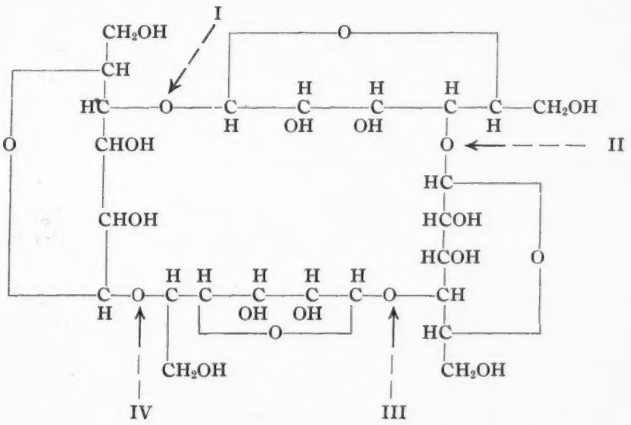


By etherification



Analyses of the xanthoanilides have shown that there is one xanthoanilide group for each C_{24}. A study of the action of concentrated HNO_3 acid on cellulose in the cold has pointed to this difference also. H. T. Clarke[33] found that linters in boiling acetic acid upon washing and drying show an acetyl content equivalent to one acetyl per C_{24}.

With this evidence in mind I have suggested a formula in which one hydroxyl group should have different properties from the other eleven.



You will notice that in Irvine's formula the value of x is 3 while in that of Gray it is 4.

Herzog,[34] by studying the X-ray diagram given by cellulose, came to the conclusion that the molecular unit of cellulose must be one, two, or four, but never three anhydro-glucose groups. Sponsler and Dore,[35] by the same means applied to ramie, arrived at 8 as the unit cell of cellulose. They consider this substance to be made up of anhydro-glucose units in the form of amylene oxide rings apparently united by primary valences in chains of indefinite length. These chains are parallel to the

longitudinal axis of the fiber. The ramie fiber is a hollow cylinder in which the crystal units are so placed that one of the diagonals of the unit cell always occupies a tangential position. They state that a group of eight anhydro-glucose units is the simplest unit that can represent the structure of cellulose. The authors consider that the continuous primary valences account for the tensile strength of the fibers in a longitudinal direction while they are stabilized laterally by the secondary valences between the oxygen atoms of adjacent chains. Ester formation is shown to be possible. This may decrease the secondary valence force with a consequent separation of the longitudinal chains and a resultant weakening of the fibrous structure.

Recently G. L. Clark[36] has come to the conclusion that the unit cell contains four $C_6H_{10}O_5$ groups.

An authoritative review of this field has been recently presented by Sir William Bragg.[37]

Hess[38] and his co-workers, by dissolving cellulose in cuprammonium, studying the optical rotations of the solutions, and calculating the ratios of copper to cellulose, have arrived at the conclusion that cellulose is monomolecular; in other words, anhydro-glucose. He explains the formation of cellobiose octa acetate on the grounds that two units, while changing from anhydro-glucose to glucose, unite to form this substance. When one considers that the acetolyzing mixture is a very powerful hydrolytic agent and that cellobiose is hydrolyzed by it, one doubts very much if it is formed in this way.

The formula suggested by Gray is in accord with the chain theory. It is believed that its contribution is in making one oxygen bridge in each group of four different from the other three, thus accounting for the seeming difference of one hydroxyl per four $C_6H_{10}O_5$ groups.

I have endeavored to give briefly the salient points of the chemistry of cellulose which have led to a better structural understanding of this material. But until we are able to show absolutely the linkage of the oxygen bridge in glucose and the value of x in the empirical formula, any structural formula is purely speculative as far as these factors are concerned.

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THE RELATION OF COTTON TO SYNTHETIC FIBERS*,[1]

CHARLES E. MULLIN, CLEMSON COLLEGE TEXTILE SCHOOL, CLEMSON COLLEGE, S. C.

There are many aspects of the relation of cotton to the synthetic fibers but probably the three points of greatest interest at the present time are: (1) The improved appearance of many cotton goods and the increased sale and utilization of these goods by the use of the synthetic fibers with the cotton in the construction of fabrics, etc. (2) The increasing competition between cotton and the synthetic fibers. (3) The fact that both cotton and rayon are composed of the same chemical compound, cellulose.

* Contribution to the symposium on "The Relation of Cotton to Chemistry," held jointly by the Division of Cellulose Chemistry and the Division of Chemical Education, at the 79th Meeting of the A. C. S., at Atlanta, Georgia, April 9, 1930.

[1] All rights reserved by author.

Of these three more or less separate and distinct relationships, the first is of general interest to the public and of particular interest to the manufacturers of and dealers in cotton goods. The second is of special interest to the cotton growers, spinners and weavers, and the manufacturers of the synthetic fibers. The third is of particular interest to all chemists and particularly those engaged in research or other problems in connection with the synthetic fibers and their manufacture, those engaged in the cotton industry, etc. As time and space are limited, the present paper will be confined to the above three subjects with particular attention to the chemical.

Cotton and Synthetic Yarn Statistics[2]

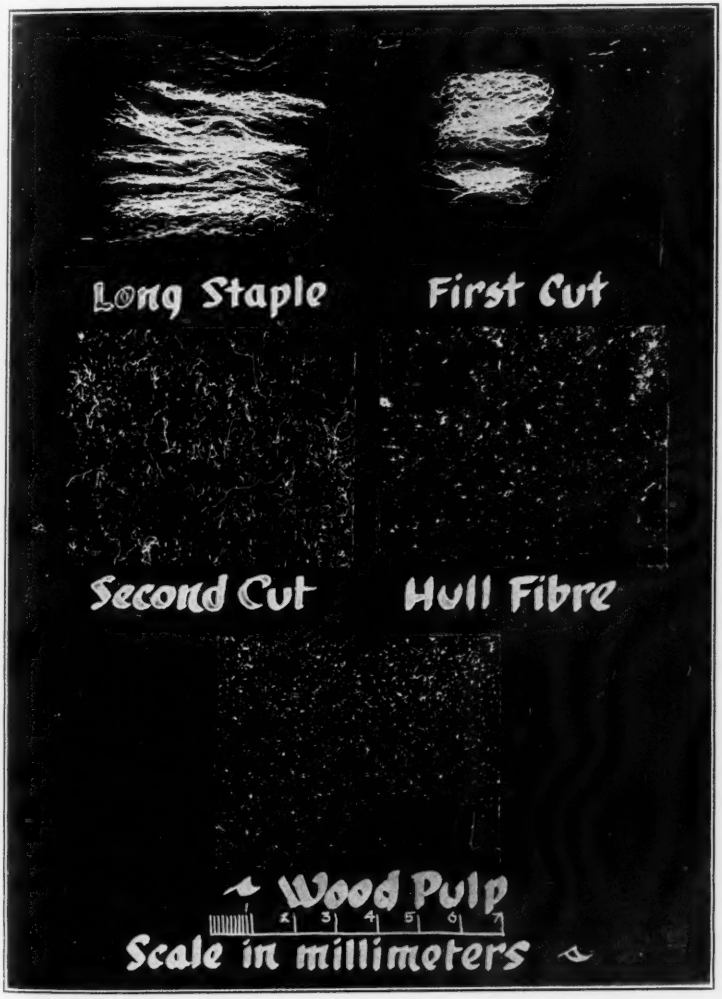
The commercial production of the synthetic fibers may be said to date from about 1891, in which year approximately 31,000 pounds were produced. The production for 1929 was 404,155,000 pounds. The manufacture in America may be said to date from about 1911, in which year 300,000 pounds were produced. The estimated production for 1930 is 162,350,000 pounds, valued at $190,000,000.

A study of statistical data[2] shows a tremendous increase from year to year in the synthetic fiber production and this progress still continues. Undoubtedly this increased production is entirely due to the increased use of the synthetic fibers with cotton (relation 1 above) and other fibers, as well as alone in various fabrics, etc. In 1929 the United States manufactured more synthetic yarn than Italy and England combined, the two next largest producers. Although there have been many reasons for this increasing use of the synthetic fibers, to both the advantage and disadvantage of the natural fibers, some of the most important causes are the improvement in both the quality and appearance of the synthetic yarns and the concurrent lowering of prices within recent years. These very desirable results are almost entirely due to chemical and other research in the synthetic fiber industry. Such research is almost entirely lacking in the more or less closely related cotton, as well as other parts of the textile, industry.

Advances in the Synthetic Fiber Industry

Not all of the changes in the synthetic fiber industry are even indicated

[2] The following nine tables of data have been omitted from this article due to space limitations: **Table I,** World Production in Pounds of Synthetic Fibers, 1892–1929; **Table II,** Synthetic Yarn Production in Pounds and Value in the United States, 1911–30; **Table III,** Synthetic Fiber Production by Leading Companies in the United States; **Table IV,** Plant Locations (U. S.) and Type of Yarns Produced; **Table V,** Estimated World's Production of Synthetic Fibers by Countries and Processes for 1929; **Table VI,** World's Synthetic Fiber Production in Pounds by Countries for 1926–29; **Table VII,** World's Production of Cotton in Pounds by Countries for 1925–28; **Table VIII,** Cotton Production in the United States for 1900–29; **Table IX,** World Production in Pounds of Textile Fibers for 1925–28. These data may be secured from the author.



VARIOUS STAPLE LENGTHS OF DIFFERENT TYPES OF COTTON

by the statistical data referred to above. One rather sudden and very considerable change in the synthetic fiber industry is the sudden interest in the acetate type of synthetic yarn by practically every large manufacturer of the rayons in the world. While the acetate type of yarn was manufactured before the World War, its commercial success may be said to date from about 1920 or 1922. At that time the acetate process was probably the most expensive of any then in use, but with the many advances in this field the process now used for the production of Celanese brand of acetate yarn probably gives a lower total cost than that of any other type. This fact, together with the superior qualities of the Celanese brand acetate silk, has attracted the attention of practically every synthetic yarn manufacturing group in the world, with the result that almost all of them have conducted experiments along this line. Judging from the fact that the Celanese Corporation of America produced about 7,000,000 pounds of yarn and made a profit of about $5,000,000 in 1929 it would appear that the actual cost of producing a pound of Celanese yarn is very low, say less than 60 cents for 150 denier yarn.

Another tendency in the synthetic yarn industry is toward finer filaments and more of them in the thread or yarn. The progress in this field has been so remarkable that it is now possible to produce filaments by the cuprammonium process which are 2.5 times finer than those of true silk. These filaments are produced on a commercial scale both in America and abroad, and are sold as 15-denier 25-filament Bemberg yarn. It requires more than 4225 miles of one of these filaments to weigh a pound.

Many other new and interesting products, such as the dull-luster and hollow (Celta) types of synthetic fibers have also aided and increased the interest and sale in these products. Recently the sale of undesulfurized viscose type yarn, particularly to the knitting trade, has assumed considerable volume. This sulfur-viscose has a higher tensile strength than the desulfurized yarn and, therefore, offers certain advantages in handling. It is desulfurized before dyeing and finishing the goods.

In spite of the tremendous increases in the production in the synthetic yarns, year after year, the saturation point for these products is still in the far-distant future. This is entirely due to the chemical and other research upon which the whole industry is based and which is responsible for each and every advance in the entire industry. It is very probable that up to the present time the sale of synthetic fibers has not, on the whole, decreased the sale of cotton goods but, on the other hand, may actually have stimulated the sale of the cottons due to the improved appearance and desirability of the otherwise more or less plain cotton goods.

In visiting cotton mills in all parts of the world one cannot help but be impressed by the large proportion of the successful mills that are using the synthetic fibers in some way wherever possible, either alone or in com-

bination with other yarns. The public today in all parts of the world, and particularly in America, is demanding new and novel materials, color schemes and effects which were never before attempted, and the various types of the synthetic fibers meet this demand admirably. Without their aid, many of the beautiful and inexpensive materials which so tempt the ladies would be impossible and, therefore, the volume of the present cotton trade considerably reduced.

The world's production of textile fibers is so enormous that in spite of the tremendous increases each year in the amount of synthetic yarn produced, the production today is still probably somewhat less than 3 per cent of the total. But this percentage is steadily growing at a very rapid rate and it is very probable that, with the decreasing costs of synthetic yarn production and concurrent improvements in the quality of the fiber, as well as the increasing costs of raising cotton in all parts of the world, we may expect this percentage of production to increase more rapidly in the future than at any time in the past. Undoubtedly there will come a time when the synthetic yarns will become real competitors of the cotton yarns for many purposes. (Relation 2.)

Economic Aspects of Cotton and the Synthetic Fibers

Within the past few years it has repeatedly been suggested that sooner or later the synthetic yarns would largely or perhaps almost entirely supplant those of certain natural fibers, particularly cotton. While this is not yet possible, it at least appears much more probable today than at any time in the past.

As is usually the case, the cost of producing viscose rayon varies widely in different plants and one company, which has a very economical finishing process, has recently announced that it can produce viscose yarn at a lower price than that of medium or fine cotton yarns of the same size. At the same time it is possible that Celanese brand acetate yarn may be produced at about the same price at present and that this cost may be lowered considerably in the near future.

While this economic development in the field of yarns is of considerable interest to the synthetic fiber manufacturers, due to the fact that it apparently widens the sales and manufacturing possibilities enormously on the basis of price alone, it is not nearly as good news for the cotton growers and spinners. Cotton has long been our cheapest and most widely used textile fiber but just at the present time there is a considerable over-production of cotton. The prices of the synthetic yarns have dropped greatly in the past year and every such reduction will tend to increase their use where cotton was previously preferred. This is certainly not good news for the American cotton growers.

Just about here the assistance of the synthetic fibers in the marketing

of cotton goods (relationship 1) ceases to be the predominating influence and it becomes a matter of competition between the natural and synthetic fibers (relationship 2). Already in China, Japan, and some other countries the manufacturers of the cheaper real silk materials are complaining of the inroads of the synthetic yarn fabrics on their sales and as soon as the price of the synthetic yarns drops to near that of the cotton yarns of the same size, the same will be true in the case of cotton goods.

Chemical Constitution of Cotton and Synthetic Fibers

Probably the closest relationship between cotton and the regenerated cellulose rayons (nitro, cupra, and viscose) is in their chemical constitution (relationship 3). All of these rayons and cotton are composed of cellulose and are chemically identical, so far as our present chemical methods show. Physically they all differ somewhat from each other and from cotton.

Cellulose, as every chemist knows, is composed of carbon, hydrogen, and oxygen combined together in the proportions of $C_6H_{10}O_5$, to form the structural group of the carbohydrate. It is also known that there are three hydroxyl radicals present for each of these anhydro-glucose groups, so that in many respects and chemical properties cellulose more or less closely resembles an aliphatic alcohol.

Just how these anhydro-glucose groups are united to form the cellulose molecule, or just what constitutes a cellulose molecule, no one can prove at present. Certain properties, reactions, and compounds of cellulose, such as cellulose xanthate, indicate that four of these anhydro-glucose groups are united, probably through oxygen to carbon atoms in the 1,4 position, to form either the cellulose molecule or a unit in this molecule. The molecular weight of cellulose has not been settled as yet.

The most active groups in the cellulose molecule appear to be the hydroxyl radicals just mentioned and it appears that one of these is primary and the other two secondary. Aldehyde, ketone, and carboxyl radicals appear to be absent from the normal or unaltered cellulose. From the above it is apparent that although cellulose is a carbohydrate, it more closely resembles the aliphatic alcohols, and particularly the polyhydric alcohols, in its chemical reactions than it does any other type of organic compound.

Even a brief comparison of the chemical reactions of such a simple and well-known compound as ethyl alcohol with those of cellulose proves this to be correct. Just as the simpler alcohols yield aldehydes and acids by oxidation, so does cellulose yield aldehyde-like products upon limited oxidation. Further oxidation gives alkali-soluble products which may contain carboxyl radicals. These aldehyde radicals account for the reducing power of oxycellulose and the carboxyl radicals explain the solubility of oxycellulose in alkalies.

Reducing Power of Degraded Cellulose

Careful hydrolysis of cellulose gives a yield of about 95 per cent glucose which we know contains an aldehyde group. Therefore, it appears that in the degradation of cellulose the anhydro-glucose ($C_6H_{10}O_5$) groups separate by hydrolysis, breaking one bond of the oxygen which formed the bridge between the groups, with the formation of the aldehyde group of glucose. This fact accounts for the reducing power of degraded cellulose as well as its other aldehyde-like reactions without any greatly involved explanation or theories.

It is well known that most of the carbohydrates are easily oxidized in the presence of alkalies or in an alkaline solution and cellulose is no exception in this respect. This is well illustrated by the ease with which oxycellulose is formed in kier boiling cotton, the oxidation occurring in the aging of alkali-cellulose crumbs in the viscose process, and the changes which occur in cuprammonium cellulose solution upon exposure to the air.

We know a lot of other facts regarding the chemical constitution and reactions of cellulose and its derivatives and degradation products but as we do not know its molecular weight it is very difficult to illustrate these by means of equations, especially as the cellulose is always in the form of micelles or complex aggregates, the colloidal state.

Physical Structure of Cellulose

Recent physical measurements of cellulose structure, by means of X-ray diffraction diagrams, indicate that there is a repetition of similar structures along the axis of all of the cellulose fibers studied and that these small structures have a length of 10.3 Angström units and right-angle dimensions of 8.7 and 7.3 Angström units. As two superimposed glucose residues measure 10.2 by 3.6 Angström units, these measurements appear to substantiate the previously mentioned fact that in certain ways cellulose appears to react as if it were composed of units consisting of four anhydro-glucose ($C_6H_{10}O_5$) groups.

Other measurements indicate that these units are connected together to form longer and wider aggregates or micelles of varying size. For example, Mark[3] believes that these micelles are formed by the linking together of 25 to 30 long chains, each composed of 50 to 100 anhydro-glucose groups.

Fox[4] writes "that 1500 to 2000 glucose residues arranged in 40 to 60 cellobiose chains each having 30 to 50 glucose residues is approximately the constitution of the micelle." In a footnote he adds that "it appears to be possible, *a priori*, that the micelle size may be found eventually to have

[3] Mark, *Textilberichte*, **11**, 695 (1929).

[4] Fox, *J. Soc. Chem. Ind.*, **49**, 84T (1930).

a much greater range. There may be much smaller as well as much larger micelles. In the meantime it is to be supposed that the α-cellulose XXX of wood pulp has not necessarily the same micelle size as the α-cellulose of, *e. g.*, cotton; the drastic digestion process for preparing wood cellulose will certainly have an effect even if its original micelle size, *in situ* in the plant, is the same, and *mutatis mutandis* for other celluloses." The above hypotheses are of particular interest in connection with Hall's hypothesis which will be discussed later.

The varying length of these chains and micelles serves to explain the argument which still exists regarding the chemical identity of the cellulose from all sources. Levinstein[5] states this very concisely. "We thus arrive at the conclusion that what we call cellulose is not a definitely characterized chemical individual. It is a collective name of a closely related series of compounds which by imperceptible graduations merge one into another. It is, in short, the name of a solid solution of many polymers." Thus, while the cellulose from most or even all sources may consist of this same mixture, the proportions of long, short, and intermediate chains may, and very probably do, vary in cellulose from different raw materials.

The Cellulose in Cotton, Rayon, and Wood

Theoretically, as cellulose from all sources is supposed to be identical, it should be possible to prepare the synthetic fibers from cellulose from any source and it is possible that this could be done, although it is improbable that all of the yarns would be satisfactory and it is certain that they would not be identical in their properties.

In actual practice cellulose from only three different sources has been used in the commercial manufacture of viscose rayon and although the cellulose from wood can be substituted for that from linters, or vice versa, the yarn manufacturing process must also be altered in order to obtain a satisfactory yarn, and even with these changes the yarns prepared from cellulose from these two sources are never identical.

There are many reasons for these differences in the cellulose from various sources which are apparently more physical than chemical, but aside from the probable physical differences in the original cellulose in the plant both the qualitative and quantitative variations in the non-cellulosic material present in the plant with the cellulose are also undoubtedly very important. The purification processes for cellulose from cotton linters and from wood differ widely, and undoubtedly in every case these processes exert some physical, and probably chemical, action upon the alpha cellulose itself as well as upon the non-cellulosic material.

Furthermore, the "purified" cellulose is never 100 per cent alpha cellulose and these remaining traces of various constituents undoubtedly also

[5] Levinstein, *J. Soc. Chem. Ind.*, **49**, 55T (1930).

have some effect upon the resulting yarn. It is interesting to note that even such slight differences in the source of the cellulose as the latitude of growth to a considerable extent affect its desirability for the manufacture of synthetic yarn, the same variety of wood grown in northern latitudes being much preferred to southern wood.

In other words, while the so-called cellulose from linters, wood, and straw may be identical chemically, so far as we can tell the forms are certainly not identical when it comes to the manufacture of the synthetic fibers and cellulose compounds. Probably this difference is largely due to either variations in the length of the "chains," the size of the micelles, or some other as yet unknown factor.

Hall's Hypotheses

A. J. Hall has recently developed a hypothesis to explain certain facts concerning some of the properties of the rayons which, to say the least, is extremely interesting and fits in very well with the foregoing facts, theories, or hypotheses, whichever you may care to call them. This hypothesis was advanced in a recent address which apparently has not yet been published in full.

Briefly, Hall's hypothesis assumes that the filaments of the synthetic fibers are built up of micelles or aggregates, the length of which is considerably greater than their breadth and thickness or diameter. This agrees with all of our present knowledge upon the subject. He also believes that the physical properties of these fibers depend to a large extent upon the arrangement of these rod- or ribbon-like micelles within the filament, which is certainly very plausible.

According to this hypothesis, the greater the number of micelles having their longitudinal axis parallel to the axis of the fiber, the greater will be the luster, tensile strength, and creasability of the fiber. The more disorderly or less systematic the arrangement of the micelles in the filament, the greater its affinity for dyestuffs, and the lower its luster and creasability.

The arrangement of the micelles in the filament is largely determined at the time of spinning and by after-treatment of the fiber. In this connection stretching, either during spinning or later, plays an important part, for the reason that by stretching the micelles are brought more and more into parallelism with the axis of the fiber. It has long been recognized that any stretching of the filaments, either during spinning or later, considerably alters many of their properties, including both luster and dyestuff affinity.

Stretching has long been used as a method of increasing the luster of the synthetic fibers during the finishing of the yarn in manufacture, and many a cloth weaver and finisher has found tension to be the cause of "shiners" in the fabric, to his sorrow. On the other hand, tension reduces

the dyestuff affinity of the yarn and is often the cause of uneven dyeing and "barriness" in dyed rayon fabrics. The stretching of Celanese brand yarn before treating it with boiling water reduces the loss of luster in this treatment.

Rayon yarns produced by the stretch process have a greater tensile strength but less stretch than those manufactured without tension. This is well illustrated by the Lilienfeld viscose yarn which is stretched while in the plastic condition, due to the presence of a sulfuric acid precipitating bath of such strength as to partially gelatinize the freshly formed filaments, and thus assist in the micelle rearrangement by the less rigid structure within the fiber.

Hall has investigated his hypothesis by the measurement of the softness, "self-supporting curves," "crease traces," etc., which definitely show that stretching the filaments very markedly decreases the resistance of both viscose rayon and acetate type synthetic fiber to creasing and at the same time reduces their softness.

That Hall is not alone in believing that the arrangement of the micelles in the filament is of importance is indicated by several patents issued recently, the purpose of which is to control to at least some extent the arrangement of the micelles in the filament during spinning.

Problems in Cellulose and Synthetic Fibers

To the teacher directing research, the research chemist, or any one else interested in work along the lines of general chemistry, colloidal chemistry, or a combination of the two, cellulose and the synthetic fibers probably present more interesting problems than most other branches of chemistry. They present such a multiplicity of problems that it seems useless to start to enumerate them.

What is the real molecular weight of cellulose? How can we prove or disprove that our present "cellulose" is a mixture of polymers? Are the proportions of these polymers the same in cellulose from different sources? What is the effect of various chemical and mechanical treatments upon the state of aggregation of the cellulose? What is the difference between the normal cellulose in cotton and the cellulose regenerated from alkali-cellulose and other compounds? What is the difference between the cellulose from northern and southern woods? Is there really only one cellulose?

How can cellulose be obtained in the pure state with the least possible degradation? What are oxycellulose and hydrocellulose? What is the arrangement of the micelles in cotton and rayon? What new varieties of synthetic fibers are possible? What are the properties of many of the cellulose esters, ethers, and other compounds and derivatives? Is any of the moisture (regain) in cotton or the synthetic fibers in chemical combination with the cellulose? What are the effects of varying pH in the

alkaline boiling of cotton? What is the cause of the differences in the action of sodium and potassium hydroxides on cotton and regenerated cellulose?

What is the best pH for bleaching cotton and linters? What is the true theory of dyeing cotton and other cellulosic fibers? What is the function of salt in the direct dye bath? What are the causes of the variations in the dyeing properties of viscose rayon from the same plant and process? What is the effect of various treatments upon the isoelectric point of cellulose? Why do solvents not remove the wax from the unaltered cotton fiber more quickly? Do you insist upon any more problems? If so, I will be glad to supply them. We know so little about cellulose, cotton, and the synthetic fibers, or any of the other textile fibers for that matter, that it is useless to hope that all of the questions will be answered in our generation.

THE COTTON CROP AND OUR FOOD SUPPLY*

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A cotton crop of fifteen million bales furnishes the oil mills with five million tons of seed. This seed produces, under present methods of manufacture, three hundred and eight pounds of oil per ton of seed, or thirteen pounds of fat for each inhabitant of the United States, taking one hundred and twenty millions as our present population. Improved manufacturing methods would yield 15 per cent more oil and allow the utilization of the nine hundred thousand tons of protein present in the seed for human food, supplying approximately one-half the protein needs of the country. Experiments made on a semi-commercial scale show that these results are possible.

RELATION OF COTTON TO LACQUERS†

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In developing the relation of cotton to lacquers, it is of first importance to define a lacquer. Up to within the past few years a lacquer in the public

* An abstract of the author's contribution to the symposium on "The Relation of Cotton to Chemistry," held jointly by the Division of Cellulose Chemistry and the Division of Chemical Education, at the 79th Meeting of the American Chemical Society, at Atlanta, Georgia, April 9, 1930, is published herewith in order to complete our account of the meeting. The complete article may be found in the *Oil & Fat Industries*, **7**, 217–8 (June, 1930).

† Contribution to the symposium on "The Relation of Cotton to Chemistry," held jointly by the Division of Cellulose Chemistry and the Division of Chemical Education, at the 79th Meeting of the A. C. S., at Atlanta, Georgia, April 9, 1930.

mind was associated with the coating on various objects of art originating in eastern countries such as Japan and China. The coating or finishing of these products, lacquering as it was called, had been developed to a fine art, and its beginnings are far back in history. The lacquer of the Japanese or Chinese is based on the juice of a native tree known as the "tsi ziu" of China or "Urushi no ki" of Japan, a species of poison sumach called "rhus verniciferus," Japanese varnish tree, and is in no sense the product of the industrial chemist. On the other hand, the present-day lacquer of the modern industrial age is distinctly the product of the research laboratory and of modern chemistry, and is an excellent example of the industrial results obtained through use of such tools.

Definition of Lacquer—Relation to Cotton

A lacquer, in the present-day sense, is a liquid material which when applied to a surface will deposit in a relatively short space of time a continuous film, through evaporation of its liquid portion. Generally, the liquid portion is an organic material and the film-forming constituent is colloidally dispersed in it. Under this definition any organic solid which will disperse in a liquid medium and deposit a film could be the basis for a lacquer, but in actual practice a modern lacquer is based on the use of cellulose nitrate for this purpose. It is through this association that cotton has become an important raw material for the manufacture of lacquers. In discussing the relation of cotton to lacquers, therefore, it is logical that the discussion should center around cellulose nitrate and its manufacture.

Cellulose Nitrate

Properties for Lacquer Use.—The historical development of cellulose nitrate since its first reported discovery in 1846 (*6*) has been covered in great detail in the chemical literature (*8*). There are, however, a number of generalized observations drawn from the empirical experience of the workers in the lacquer field that should be emphasized in this discussion. They can be summarized as follows:

1. Cellulose nitrate commonly used for lacquers is not a simple chemical compound with a definite number of nitrate groups attached to the cellulose radical. It consists of a mixture of nitrates, and its properties are a resultant of the properties of the constituent nitrates. The lacquer chemist has found by experience that the solubility characteristics of the nitrate will vary with the percentage of average nitrogen present in the product, and that for lacquer work an average nitrogen content between the limits of 11.4% N to 12.4% N gives solubilities in organic solvents best adapted to his needs.

2. Cellulose nitrate used for lacquer must be chemically stable, that is, not decompose under conditions of use over a long period of time. This

was also of utmost importance in connection with explosives, the field in which cellulose nitrate found its earliest use, and the knowledge gained in obtaining a properly stabilized product has proved invaluable in later application to lacquer work.

3. Cellulose nitrate within the nitrogen limits mentioned and dissolved or dispersed in organic solvents will deposit a clear transparent continuous film of high-tensile strength, quite flexible, and very resistant to the action of moisture and ordinary variations in temperature. The physical constants of this film, particularly permanent retention of flexibility as measured by a bend test, should be of highest value and are related to the durability of lacquers. The thickness of the film is dependent on the cellulose nitrate content of the depositing solution, which in turn is related to the viscosity characteristic of the cellulose nitrate in organic solvents.

4. The viscosity or consistency of dispersions of cellulose nitrate in organic liquids bears no relation to the chemical constants of the molecule; nitrates of the same percentage nitrogen content varying in viscosity of solution from that of water to that of heavy tar. This viscosity characteristic is apparently a property of the cellulose portion of the molecule, and at the present writing explanation of the differences lies in the field of speculative chemistry, awaiting the necessary experimental work.

Relation to Modern Lacquers.—Making use of the four generalizations given, the lacquer technologist has been able to draw up certain specifications to guide the cellulose nitrate manufacturer in the type of product which should be used; and through these, to some extent, in the selection of the type of cotton for manufacture of the nitrate. It is interesting to note that although fairly exact information on the relation between the percentage nitrogen content and solubility in organic solvents, as well as sufficient knowledge of proper means of producing stable cellulose nitrate, has been available for many years, it is only within comparatively recent years, since 1919 (*1*), that a sufficient amount of knowledge on viscosity characteristics has been obtained to permit the manufacture of cellulose nitrate below a limiting viscosity. This important discovery marked the beginning of the modern lacquer industry, since it was possible to formulate lacquers, sufficiently high in cellulose nitrate content, to be applicable in industries such as the automobile industry under practical economic conditions. The growth of the use of lacquers since that date has made the industry of some importance as a consumer of cotton.

Cotton for Lacquer Cellulose Nitrate

The actual selection of cotton as a source of cellulose for the nitrate of the lacquer industry bears little relation to lacquer. It is an outgrowth

of the earlier uses of cellulose nitrate in the celluloid and smokeless powder industries. In the early days of the industry the manufacturer of cellulose nitrate turned to the most readily available source of cellulose of highest purity. This was dictated largely by the factor of proper stabilization of the nitrate, which was a problem of considerable difficulty, and in the case of explosives an all-important factor in proper manufacture. Cotton proved to be ideally suited as a raw material for the purpose. Its cellulose content was high, it was low in cost, uniform in composition, and unlimited in supply, three of the most important factors in the choice of any raw material for a chemical industry.

The industry, therefore, grew up around the use of cotton. In the early days cotton rovings or slivers were used, later mill-run linters, which were in use up to the time of the World War. During that period scarcity of cotton, combined with enormously increased demand, forced the industry to the use of second-cut linters, and in the later stages of the war, hull fibers. At the present time second-cut linters are in general use for the manufacture of cellulose nitrate for lacquers.

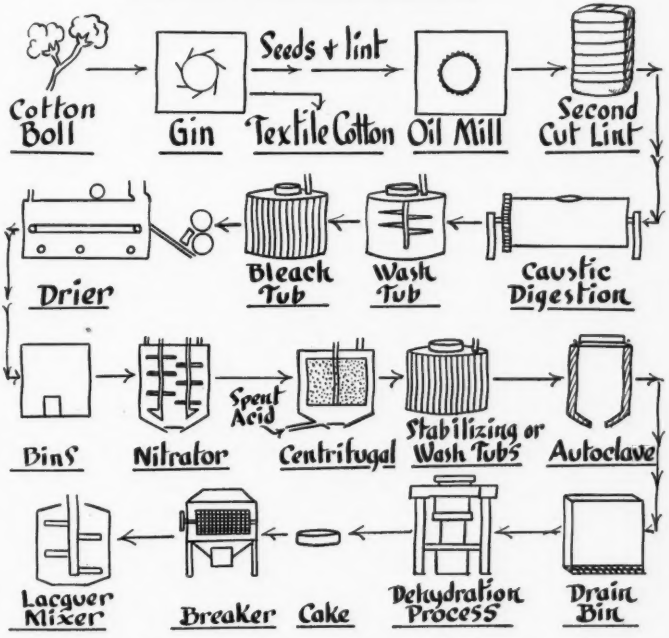
Second-cut linters have proved excellently adapted to the industry. The process of manufacture of cellulose nitrate requires as a starting point for the cellulose a raw material of certain definite staple length. This will be better understood if a brief review of the method of manufacture of cellulose nitrate from cotton is given. Figure 1 is a flow sheet showing the various steps in the handling of cotton from the raw state to the finished cellulose nitrate. It will be noted that a large number of handling operations are necessary. This mechanical handling requires a starting product capable of withstanding mechanical degradation sufficiently to retain the fibrous structure on which the handling operations are based. Not only that, but nitration is usually effected at an elevated temperature which serves further to attack the fibrous structure. The consequence is that the manufacturer of cellulose nitrate is by the nature of his process forced to select as a starting point for his cellulose, a product capable of passing through the different operations with the minimum production of fines which result in losses. It can be easily seen, therefore, that second-cut linters which are a by-product of the cotton industry as a whole are excellently adapted to the needs of the manufacture of cellulose nitrate. At the present time, even though numerous new uses have developed causing an increase in price, they still remain the primary source of cellulose used in the lacquer industry.

Composition and Treatment of Linters

Second-cut linters used in the cellulose nitrate industry come to the manufacturer in bales just as taken from the cutters in the oil mills. The lint is purchased through brokers and while no attempt is made to

— Figure I —

Flow Sheet - Cotton - Manufacture of Cellulose Nitrate



Manufacturing Cycle from Lint ~ 48 Hours

Pounds water per pound Lint ~ 400 lbs.

Pounds acid per pound Lint ~ 1.0-1.5 lbs.

purchase on specification, advantage has been taken in recent years of the grading work of the Bureau of Agriculture in an attempt to obtain lint of definite standard for a certain price. The nitrate manufacturer is interested in the available cellulose content, and that the product will contain a minimum of dirt and trash. There has been some discussion in the lacquer industry of the advisability of selection of linters from a specified locality, but there does not seem to be any logical reason for this. Table I gives a comparison of the chemical constants of a series of samples of second-cut linters taken from various sections in the southern states. When these samples were purified and nitrated, cellulose nitrate of practically identical quality was obtained from each sample.

TABLE I

Analysis Linter Samples

Source	*Moisture**	*Ash*	*Ether extract*	*Approximate cellulose*
Chickasha, Okla.	9.07%	1.603%	0.714%	90.97%
Friars Point, Miss.	4.68	1.036	0.584	93.14
Greenwood, Miss.	8.06	1.668	1.860	90.07
Childress, Tex.	5.16	1.707	1.505	88.52
Plainview, Tex.	5.60	2.158	0.784	86.54
Dallas, Tex.	5.21	1.440	0.810	90.34
Macon, Ga.	4.92	1.318	0.950	91.12
Montgomery, Ala.	5.09	1.700	0.770	90.93
Raleigh, N. C.	6.09	1.23	0.710	90.99
Hull Fibers	7–9	2.20	2.54	77.56

* Moisture shown on air-dry basis. Others shown on bone-dry basis.

The purification process used in preparing linters for nitration consists of a mild caustic treatment in the absence of air and at elevated temperature, followed by necessary washing and bleaching treatments. In general, it follows the process commonly used to obtain a purified cellulose from any fibrous material, namely caustic treatment to remove waxy impurities followed by washing, with a final bleach treatment to obtain an absence of color. Table II gives an analysis of a typical purified cellulose obtained from cotton linters through the use of this process. For purposes of comparison an analysis of very high alpha cellulose obtained from wood

TABLE II

Analysis—Available Celluloses for Nitration

Material	*Alpha cell*	*Beta cell*	*Gamma cell*	*H_2SO_4 insol.*	*Ash*	*Ether extract*
Purified Linters	94.5%	5.0%	...%	0.25%	0.25%	0.3%
High Alpha Wood Pulp	94.0	1.5	4.5		0.10	0.15
Wood Pulp, Ordinary Grade	84.8	3.19	10.31	0.92	0.14	0.64
Wood Pulp, Special	87.5	3.5	8.5	..	0.15	..
Vegetable Fiber	95.3	3.4	0.56	0.33	0.19	0.23

pulp as well as an analysis of an ordinary type of wood pulp cellulose used in the paper trade are also given. It will be noted that a cellulose of very high purity is used in the lacquer industry.

Properties of Cotton in Relation to Cellulose Nitrate for Lacquers

Mention has previously been made that the lacquer technologist was interested in several properties of cellulose nitrate which experience had shown could be evaluated by certain empirical standards or constants, such as the percentage nitrogen content, chemical stability as measured by the resistance to decomposition at high temperatures, solubility in certain organic esters, viscosity of the solution so obtained, and finally in the physical characteristics of the film obtained from the solution. It may be of interest to touch briefly on the methods used in exercising control over these factors, and the relation of cotton in its chemical and physical characteristics to these methods.

Control of the percentage nitrogen content is not a function of the cotton cellulose. The process of nitration consists of merely allowing cotton to remain in contact with mixed sulfuric and nitric acid for a definite period of time and temperature, removing the excess acid by a centrifugal, and stopping any further reaction by immersion in an excess of water. The nitrated cellulose is then heated with water several hours to remove the water-soluble or easily decomposable esters. The ratio of nitric and sulfuric acids and water in the mixed nitrating acid, in conjunction with the temperature, determine the nitrogen content of the final product. The cotton is apparently unchanged by this treatment, fibrous character and strength of the fiber being retained. As stated by Dr. Heuser (*3*), "nitration affects cellulose, so to speak, only externally; and the molecule itself, the true framework, is not degraded. In other words the polyose character of cellulose is retained in the nitrates."

The stability of the finished nitrate is not in a strictly chemical sense directly related to the cotton used. As described above, the finished cellulose nitrate is heated with water to remove soluble or easily hydrolyzable products, until it shows no signs of decomposition at high temperatures (135°C. for thirty minutes). Provided a cellulose of high purity such as is shown in Table II is used as a starting point in the reaction, very small amounts of by-products which affect stability relations are produced. It is of course true that the nitration of a cellulose, high in oxy or hydrocelluloses may result in the formation of nitrates difficult to stabilize; but cellulose nitrate used in the lacquer industry to date has been based on high alpha cellulose, such as is so readily obtained from cotton.

Solubility of cellulose nitrate in organic esters is largely a function of the percentage nitrogen present, and this in turn as has been pointed out is controlled by nitrating acid composition and temperature. However,

the viscosity of the solutions obtained, and to a marked extent the physical characteristics of the film obtained from these solutions are apparently very closely related to the molecular or polymeric structure of the cellulose used for nitration. It is in these two fields that the cotton appears to exercise a definite and marked effect on the results obtained. Unfortunately, a clear and definite picture of the relationship between chemical and physical (in the colloid sense) structure of cotton cellulose, and the properties of viscosity characteristic and film character, is not available at the present time. It is a field of research that invites the investigator, and one that should be productive not only of valuable scientific contributions but of results of practical importance in the lacquer industry as a whole.

Importance of Viscosity Characteristics

It can be stated that the modern lacquer industry owes its present growth to the discovery of commercial methods of controlling the viscosity characteristics of cellulose nitrate. Up to 1919 all lacquer products were based on cellulose nitrate which in solution gave a relatively high viscosity. For this reason a single application of solution resulted in the deposition of very thin films. In order to obtain finishes of proper service characteristics it was necessary to apply an excessive number of coatings. As soon as methods of reducing the viscosity of cellulose nitrate, while still retaining film strength and durability, were discovered and applied in the manufacture of lacquers, the use of lacquers as a finishing medium became commercially economical, and wide adoption in many fields of industry followed. The importance of this can be shown by reference to Figure 2. This curve is based on statistics published by the Bureau of Commerce. The very rapid increase in production over the years immediately following 1923, which marked the introduction of the low-viscosity type of cellulose nitrate into the commercial lacquer field, is a measure of the importance of this discovery.

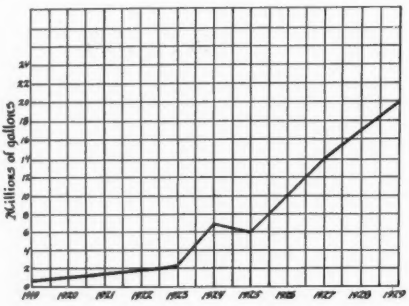


FIGURE 2.—PRODUCTION OF CELLULOSE NITRATE LACQUERS IN UNITED STATES 1919–29

Methods of reducing the viscosity of cellulose nitrate have been discussed in the technical literature (*7*) and a considerable number of patents (*1*) issued covering different processes. In general, they all require the

treatment of finished cellulose nitrate, and fall into several classes comprising action of heat alone, heat in the presence of reagents of controlled alkalinity, or the action of ultra-violet light. In the modern lacquer industry the first two methods only have found commercial application.

Cellulose Viscosity and Influence on Nitrate Viscosity

Considering this reaction, which is of such practical importance from the viewpoint of the chemist, there are a number of pieces of evidence which point strongly to the influence of the cellulose molecule or complex on the result. Gibson (*2*) has shown that the viscosity of esters prepared from cellulose is governed by that of the original cellulose as measured by the viscosity of cupra ammonium solutions. The viscosity of cellulose itself can be reduced in a number of ways (*4*) (*5*), some of them paralleling the processes of reduction of the nitrate. High temperature in the presence of inert gases is satisfactory; steeping in dilute acids can be used; oxidation in the presence of water will produce low viscosity. Nitration of the finished reduced-viscosity cellulose results in the production of low-viscosity cellulose nitrate. Further striking evidence of this is the fact that regenerated cellulose produced from viscose solutions of the rayon industry when nitrated will produce cellulose nitrate of the viscosity most commonly used in the lacquer industry. The evidence is very strong, therefore, that the viscosity characteristic of cellulose nitrate of the lacquer industry is very largely a function of the cellulose complex.

This naturally raises the question as to why the present industrial methods of obtaining low-viscosity cellulose nitrate are confined to treatment of the nitrate itself. This is due to the fact that methods of treating cellulose, prior to nitration, which will produce a product of sufficiently low viscosity to be of practical commercial application, cause serious degradation of the fiber with consequent low yields and high costs.

Viscosity Characteristics and Film Character

The close connection between the viscosity of cellulose and the viscosity of the resultant nitrate may have bearing on the character of the films produced from the different types. Table III gives generalized data obtained from measurements of the physical constants of a film produced from a number of cellulose nitrates of different viscosities. These nitrates were all produced from linters of the type shown in Table II. The reduced-viscosity nitrates were obtained by heat treatment of the nitrated product. It will be noted that no pronounced tendency in differences in tensile strength have been found, but a gradual decrease in flexibility occurs as the viscosity of the nitrate is reduced. This data is offered with no attempt at explanation of the results. An interesting problem probably

tied up with the factors of solvent retention and size of molecular complexes awaits solution here.

TABLE III

Relation of Physical Constants—Viscosity of Cellulose Nitrate

Viscosity	*Per cent N*	*Tensile strength*	*Flexibility*
1/4 sec.	12.00	6605	3.3
1/2	12.10	8636	9.5
3/4	11.70	9746	10.8
7	11.90	6960	23.2
10	12.40	9905	31.9
600	12.40	8912	57.0

Viscosity measured in solution of composition.

N/C	12.2%
Ethyl Alcohol	22.0
Ethyl Acetate	17.5
Benzol	48.3
	100.0%

Flexibility measured as number of bends in flexing devise to cracking.
Tensile strength—pounds per sq. inch. Film 0.003″ thick × 1/2″ wide.

Commercial Aspects of Use of Cotton in Lacquers

Compared to the production of cotton as a whole, the lacquer industry is not a very large consumer of cotton. The average lacquer will contain about one pound of cellulose nitrate to the gallon. To produce this nitrate requires about one pound of linters. Based on this assumption the average consumption of cotton in the lacquer industry during the years 1926–29 is shown in Table IV. Actually the consumption is somewhat less than shown due to the fact that the industry used considerable quantities of cellulose nitrate recovered from scrap film and smokeless cannon powder. This usage is actually less than one per cent of the total available cotton produced in the United States. On the other hand, it is approximately seven per cent of the second-cut linters produced and is fifteen per cent of the total linter consumption by the chemical industry as a whole.

TABLE IV

Consumption Cotton Linters in Lacquer Industry

Year	*Gallons lacquer*	*Bales linters*	*Total production bales—U. S.*
1926	16,000,000	28,100	.....
1927	17,000,000	29,800	13,000,000
1928	17,500,000	30,700	14,523,000
1929	20,500,000	35,950	14,800,000

Average bale weight—570 lb.

Future Possibilities of Use of Cotton in Lacquer

No discussion of the relation of cotton to lacquers would be complete without some attempt to forecast the future trend. At present the use of cotton linters in the cellulose nitrate industry seems firmly established. This is largely due, as has been pointed out, to the unique physical character of linters, which makes them especially adapted to the nitration process. From the chemical angle the use of other sources of cellulose is probably practicable. Table V gives physical data obtained on films produced by nitration of cellulose from wood pulp and other vegetable fiber, in comparison with films from nitrated cotton.

TABLE V

Comparison Physical Constants—Cellulose Nitrate Prepared from Cotton, Wood Pulp, and Vegetable Fiber

Source cellulose	*Viscosity*	*Per cent N*	*Tensile strength*	*Flexibility*
High Alpha Wood Pulp	20″	12.00	10,300	10.5
Cotton	20″	12.00	7,215	10.0
Regenerated Cellulose	3/4″	12.00	6,900	10.8
Cotton	3/4″	11.70	9,746	10.2
Vegetable Fiber	1/2″	12.00	7,976	10.8
Cotton	1/2″	12.10	8,636	9.5

It will be noted that film characteristics show no striking differences. The stability and service characteristics of such films are apparently satisfactory. Cellulose from these sources, however, does not lend itself to the nitration process except in the form of paper. In this form it is not as economical to use as are purified cotton linters. Until such time as the economic difference can be overcome, linters will continue to be used.

The question of the increase of use of cotton in lacquers is largely tied up with the expanding use of lacquers in industry. As shown by the curve in Figure 2 the curve of production has shown no tendency to flatten out. However, no large market hitherto untouched is in sight, and it is reasonable to assume that a slower rate of growth is in prospect. Modern industry has been quick to take advantage of the possibilities offered by lacquer, particularly in the field of mass production methods, and it can be safely stated that its adoption has occurred wherever economically feasible. It is unlikely then that any further marked increase in use will occur in the next few years. A steady growth, however, will probably continue.

Mention might be made of the possible elimination of cellulose nitrate in the lacquer industry and the subsequent effect on use of cotton. There is nothing in sight at the present time with a reasonable chance of supplanting cellulose nitrate in this field within the next few years. Certain

cellulose derivatives such as the ethyl and benzyl ethers, and cellulose acetate are being examined and considered, but no loss to the cotton industry would result through their adoption or use. It is more likely that in the case of cellulose acetate, particularly, added use will be found. Synthetic resins have so far failed to find use except in conjunction with cellulose nitrate. It can probably be safely stated that continued use for cotton in the lacquer industry seems assured for some time to come.

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THE RELATION OF COTTON TO EXPLOSIVES*

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The Discovery of Guncotton in 1846 Attributed to Schönbein

The discovery of guncotton by Schönbein (*1*) in 1846 is an historical fact of interest to both the Division of Cellulose Chemistry and the Division of Chemical Education of the American Chemical Society. Schönbein was professor of chemistry at Basel (French, Bâle), Switzerland. He announced his discovery of guncotton on May 7, 1846, at a meeting of the Society of Scientific Research at Basel (*2*). While Pelouze, who had reported the action of nitric acid on paper, linen, and cotton fibers in 1838 (*3*), disputed Schönbein's claims to discovery, the explosives industry generally regards the latter as the discoverer because Schönbein was the first to ni-

* Contribution to the symposium on "The Relation of Cotton to Chemistry," held jointly by the Division of Cellulose Chemistry and the Division of Chemical Education at the 79th Meeting of the A. C. S., at Atlanta, Georgia, April 9, 1930.

CHRISTIAN FRIEDRICH SCHÖNBEIN, DISCOVERER OF GUNCOTTON

trate cotton in a mixture of sulfuric and nitric acids and the first to actually use guncotton both as a propellant in guns and as an explosive in mines.

Schönbein did not realize the hazard involved in the manufacture and storage of guncotton. He wrote to Dumas of France about his discovery in part as follows:

> The manufacture is not attended with the least danger, and does not require any costly installations.

Work of Walter Crum, Scotland, 1847

Reference should be made to the work of Walter Crum of Scotland (*4*) who showed that guncotton was quite different from the nitrostarch discovered by Braconnot and further investigated by Pelouze. Crum's work is of particular interest because he devised the method which is now in universal use for the analysis of nitrates, nitric acid, and nitrocellulose—the decomposition of the nitrate by sulfuric acid in the presence of mercury to give nitric oxide, the volume of which Crum measured, as is done today in the nitrometer.

In the above-mentioned article Crum stated:

> The cotton I used was fine Sea Island. It was first thoroughly carded and then bleached by boiling in caustic soda and put in a solution of bleaching powder; then caustic soda again and afterwards weak nitric acid. . . . When burnt 10,000 parts left 9 of ash. The cotton . . . was exposed in parcels of 10 grains each for several hours to the heat of a steam-bath, and each parcel was immersed, while hot, into a 1-ounce measure of the following mixture: sulphuric acid (1.84) 1 measure and 3 measures of pale lemon colored nitric acid (1.517).

It is hardly necessary to mention before an Atlanta audience that the best "Sea Island" cotton that is raised anywhere in the world is a product of the State of Georgia.

Early Manufacture of Guncotton in England and on the Continent

Schönbein entered into an arrangement with Böttger, who in August of 1846 independently discovered guncotton, so that the latter would also share in the profits of the invention. He visited England where, assisted by the able engineer, Richard Taylor, numerous tests of guncotton were made in the mines of Cornwall and in small arms and guns. Negotiations were concluded with Messrs. John Hall and Son of Faversham, for the manufacture and sale of guncotton in England. The guncotton factory erected was destroyed by a disastrous explosion on July 14, 1847, and never rebuilt (*5*).

Two explosions in France the following year stopped the manufacture in that country. A German commission, of which Liebig was a member, reported unfavorably, pronouncing guncotton unstable, of uncertain force, and too expensive.

All investigations were discontinued except that of Baron Von Lenk, of the Austrian Artillery, who worked out the production of guncotton on a manufacturing scale in a factory erected at Hirtenberg, Austria. Von Lenk nitrated hanks of loose cotton yarn for 48 hours in stoneware pots. The excess acid was then wrung out in a centrifugal machine, the guncotton drawned and then washed for a period of three weeks. The skeins were centrifuged to remove bulk of water, boiled for 15 minutes in dilute potassium carbonate solution, and finally washed for several days. The guncotton magazine at Hirtenberg exploded July 30, 1862, on account of spontaneous decomposition, and after another serious explosion on October 11, 1865, the manufacture of guncotton was officially prohibited in Austria (*5*). Furthermore, the attempts to use the uncolloided guncotton as the propellant in guns were disastrous, the barrels bursting from the too rapid rise in pressure.

Frederick Abel of England Introduces Pulping Treatment

The unfortunate experiences cited above did not deter the English chemists from developing the industry. Early in 1863 Frederick Abel was requested by the British Government to take up the study of guncotton and its manufacture (*6*). The manufacture of guncotton was commenced at Waltham Abbey, England, in 1863 on a small scale, but it was not until 1872 that a factory capable of producing 250 tons a year was established there. Abel concluded that the instability of guncotton was due to the difficulty of washing out the acid and introduced the pulping process by which the guncotton was pulped in a beater and then given a prolonged washing treatment. Simple as it may seem, this was an important discovery, making the nitrocellulose safer to handle and store. Also the wet pulp could be compressed into blocks which were convenient for transportation and use.

In 1872 E. A. Brown, who was Abel's assistant, discovered that these wet guncotton blocks could be fired by a small primer of dry guncotton and the dry guncotton by a fulminate detonator (*7*). These slabs of wet compressed guncotton for many years were the standard explosive for military demolition and for mines and torpedoes until largely replaced by TNT and other high explosives.

Stabilization of Nitrocellulose by Boiling

In 1873 boiling vats were installed at Waltham Abbey and in 1878 the guncotton received two boilings by steam in wooden vats for eight hours each with change of water (*6*). In April, 1894, this system was replaced by a boiling cycle of 78 hours, characterized by short boilings at the commencement of the process, the time of successive boilings being gradually increased.

Stabilization by Acid Hydrolysis

This system of boiling was continued until 1905, when Robertson showed that the unstable sulfuric esters are decomposed more rapidly by boiling in acid water than by boiling in alkaline water (*8*). So today the stabilizing of nitrocellulose is characterized by long boilings in acidulated water, followed after pulping by alkaline and fresh water boils and numerous washings with fresh water. Nitrocellulose for smokeless powder manufacture receives a total boiling treatment of 52 hours and upward, requiring large expenditure for plant installation, steam, water, and labor. A more economical process for the stabilization of nitrocellulose is very much desired, particularly by manufacturers of smokeless powders, who give nitrocellulose a longer stabilization treatment than other users of nitrocellulose.

Nobel Invents Blasting Gelatin, 1875

The success which attended Sir Frederick Abel's work on the purification of guncotton led to renewed interest and a few years later there were discoveries of great importance to the explosives industry, one of great importance to the development of high explosives and the other of vital importance to the smokeless powder industry.

Nobel (*9*) in 1875 found that nitroglycerin could be gelatinized by dissolving in it nitrocellulose of the soluble or collodion type. The explosive compound became more and more gelatinous in proportion to the quantity of nitrocellulose dissolved in the nitroglycerin and when from 7 to 8 per cent was present, a solid jelly was formed which was found to be highly suitable as a powerful explosive. This type of explosive came to be known as blasting gelatin, a typical composition being

Nitroglycerin	91 parts
Nitrocellulose	8 parts
Chalk	1 part

The gelatinizing property of nitroglycerin for soluble nitrocellulose was later made use of in the type of explosive commonly called gelatin dynamite. In view of the brisant properties of blasting gelatin, attempts were early made to modify the same by the addition of other materials. These additions consisted of potassium, sodium or other nitrate, wood meal or other absorbent, with a small amount of chalk added to neutralize any traces of acid. A typical composition given by Naoum (*10*) is

Gelatin	Nitroglycerin	63.25 to 61.5%	65%
	Soluble Nitrocellulose	1.75 to 3.5%	
Dope	Saltpeter	27.0 to 28.0%	35%
	Wood Meal	8.00 to 7.0%	

The manufacture of blasting gelatin and gelatin dynamite requires a special type of nitrocellulose. This is similar in some respects as regards nitrogen

content and solubility in various solvents to nitrocellulose used for lacquers, but differs from the latter largely in that the viscosity is very high, while that for lacquers is very low. This high viscosity and other desirable properties have to date been only attainable using cotton linters of the best grade, in fact no other source of cellulose has been seriously considered for making nitrocellulose for use in blasting gelatin and gelatin dynamite.

Invention of Colloided Smokeless Powder

The second important discovery which has led to the extensive use of cotton was the invention of smokeless powder. The attempt to use uncolloided guncotton as the propulsive force in large guns led to disaster; the guns burst, due to the explosive action of the guncotton.

The first smokeless powder after Von Lenk's guncotton batteries was introduced by Schultze in England in 1865. It consisted at first of pellets of wood which were nitrated and then impregnated with barium and potassium nitrate, but later wood pulp was nitrated. Volkman five years later partly gelatinized the nitrated wood pulp by treatment with a mixture of ether and alcohol. The gelatinization of the nitrocotton by ether and alcohol controlled the rate of burning of the guncotton or, in other words, caused the gelatinized nitrocotton to burn more progressively.

First Military Smokeless Powder by Vieille

The first smokeless military powder was Poudre B, named after General Boulanger, invented by the French chemist Vieille in 1886 while working in the laboratories of the French Government. This powder was made by forming a dough of nitrocotton colloided by a mixture of ether and alcohol, which was then rolled into sheets, cut up into strips, and dried. Later the dough was pressed through dies into strips which were cut up and dried.

The abandonment of black powder and the substitution therefore by the French Government of a new and efficient smokeless powder attracted the attention of all civilized powers. Efforts to achieve similar results were at once inaugurated in other countries and the period of inactivity which followed the abandonment of efforts to employ guncotton as a propellant gave way to one of marked activity in all that related to the study of explosives.

"Pyrocollodion Powder" of Mendeléeff, Adopted by Russia

The Russian Government commissioned Prof. Mendeléeff, of Periodic Law fame, to conduct a series of researches with a view to the production of an efficient smokeless powder for Russia. As a result Prof. Mendeléeff developed a powder called by him "pyrocollodion" which proved satisfactory, and which was adopted in Russia. The nitrocellulose had a nitrogen content of 12.40% and was completely soluble in ether-alcohol.

EARLY POT SYSTEM OF NITRATING COTTON AT CARNEY'S POINT, DU PONT'S N. J. PLANT
Pot nitrating house.

Ballistite and Cordite

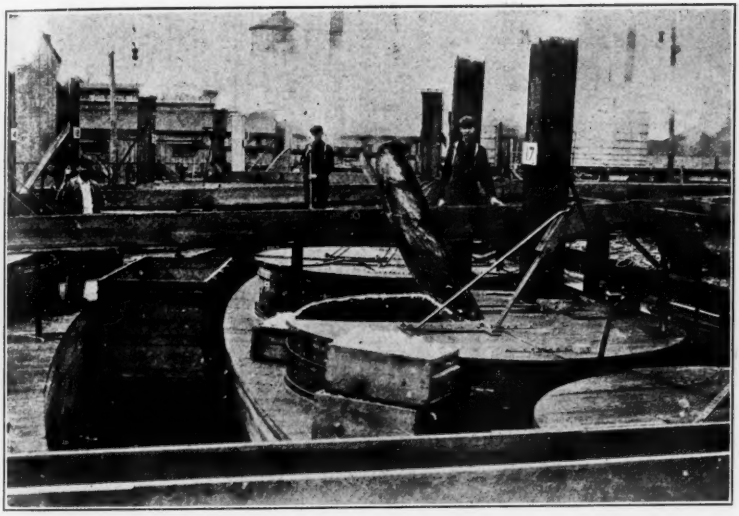
In 1888 Nobel introduced Ballistite, made by gelatinizing soluble nitrocellulose of low nitration with nitroglycerin, and in the same year the British Government introduced Cordite, made by gelatinizing insoluble nitrocotton of high nitration with nitroglycerin and acetone.

Adoption of Smokeless Powder by United States, 1899

The United States adopted smokeless powder for military use in 1899 shortly after the Spanish-American War. The powder adopted by both the United States Army and the United States Navy was of the nitrocellulose type, the nitrocellulose having a nitrogen content between 12.50-12.70% and commonly referred to by those manufacturing it as Pyro. In 1908, 0.4% of diphenylamine was added as a stabilizing agent.

Cotton, the Basis of Nitrocellulose for All Military Powders

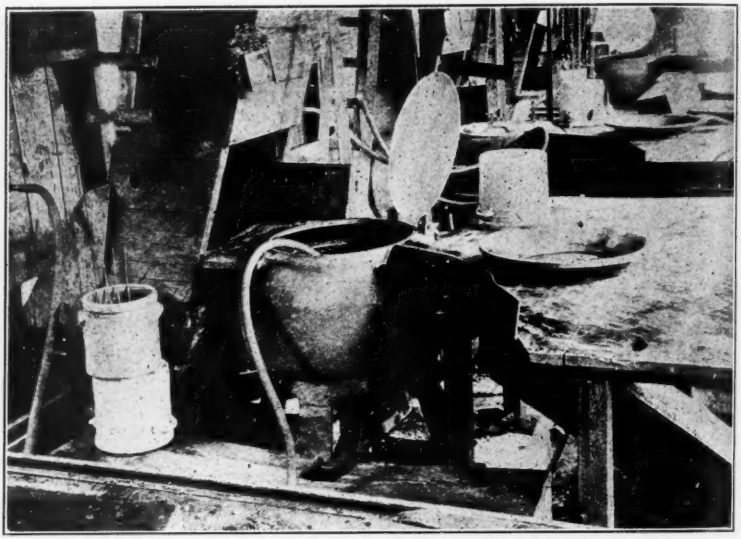
For all of the above various kinds of smokeless powder, cotton was initially used and up to the World War continued to be the accepted source of cellulose for nitrating purposes. This was also true in general of various



EARLY POT SYSTEM OF NITRATING COTTON AT CARNEY'S POINT, DU PONT'S N. J. PLANT
Old-type boiling tubs.

smokeless powders developed primarily for sporting purposes. It is of interest to note that the Schultze Gunpowder Company of England, which made the first shotgun powder in 1868, continued for over fifty years to nitrate wood cellulose for this purpose. At one time or another the explosives industry, either in this country or abroad, has studied almost every kind of fiber containing cellulose and has prepared nitrocellulose from many of them. Wood cellulose received considerable attention particularly by those nations whose supply of cotton might be cut off in time of war and its use during the war will be discussed later.

In the early days of the manufacture of guncotton and smokeless powder in the United States dating back thirty and more years ago, many kinds of cotton and different sources of cellulose were investigated. Long staple cotton, linters, and hull fiber were all studied in turn, the linters being favored because of satisfactory quality, lower initial price, and less pulping required. At one plant cotton clippings from the manufacture of underwear were for a time nitrated and made into smokeless powder. Cornpith cellulose was used in the manufacture of smokeless powder during the early days (1900) of the International Smokeless Powder & Dynamite Company (later the International Smokeless Powder & Chemical Co.), now the Parlin plant of the du Pont Company and devoted at present to the manufacture of lacquers and solvents (*11*).



EARLY POT SYSTEM OF NITRATING COTTON AT CARNEY'S POINT, DU PONT'S N. J. PLANT
Centrifugal wringer for removing spent acid from the nitrated cotton.

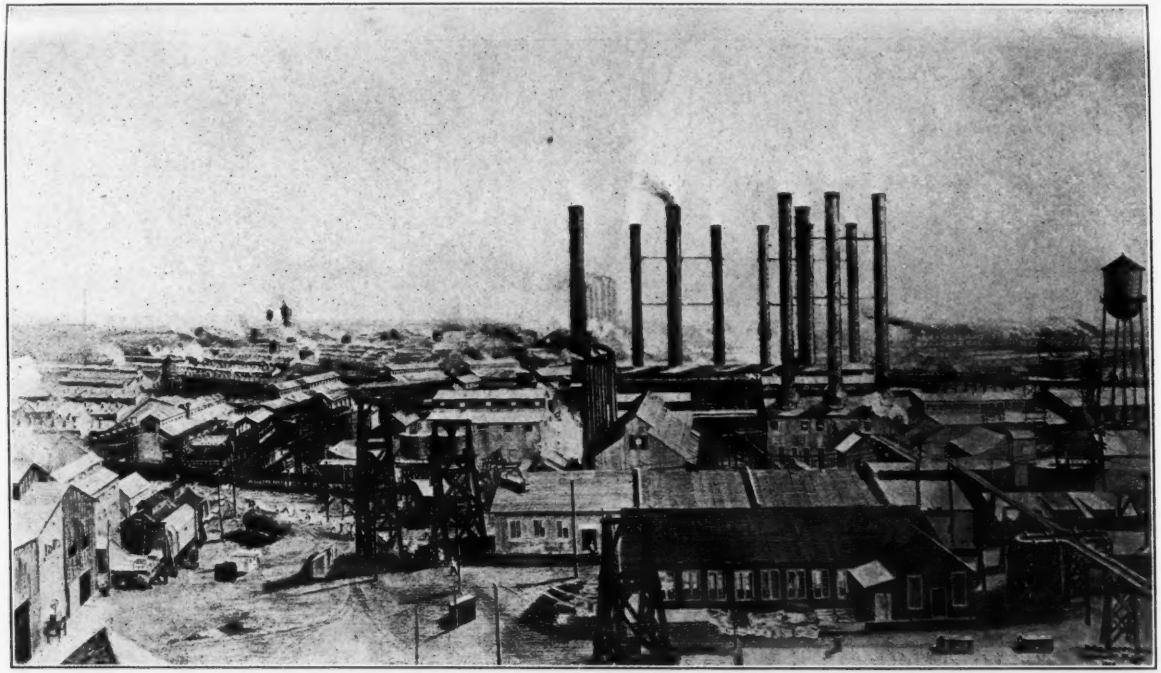
Specifications for Purified Cotton for Smokeless Powder

The explosives industry has had specifications for more than 20 years covering the quality of purified cotton used in the manufacture of smokeless powder. These specifications are familiar to many of you. During the past year these specifications have been revised, the important changes being as follows:

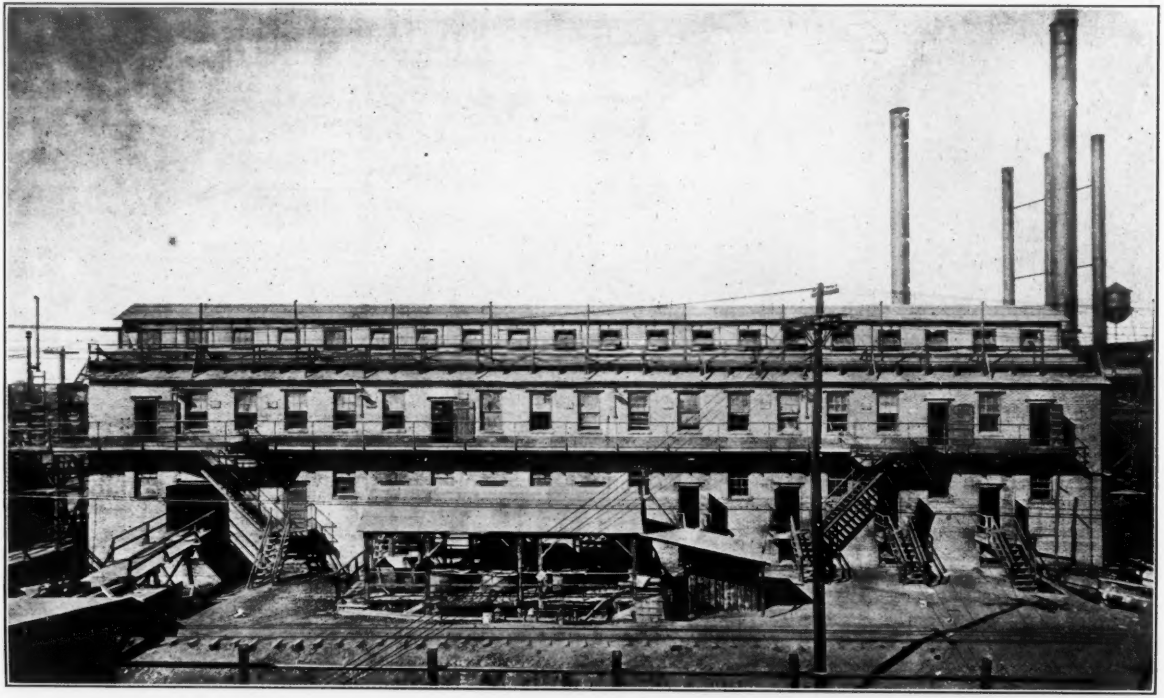
	Former specifications	*Revised specifications*
Solubility in 10% KOH, or 7.14% NaOH Solution	Less than 7%	Less than 5% unless lower figure specified in contract
Ash content	Less than 0.8%	Less than 0.5%
Ether content	Less than 0.4%	Same
Viscosity	No specification. Viscosity of cotton controlled by manufacturers	Definite specification on each contract

Viscosity Control

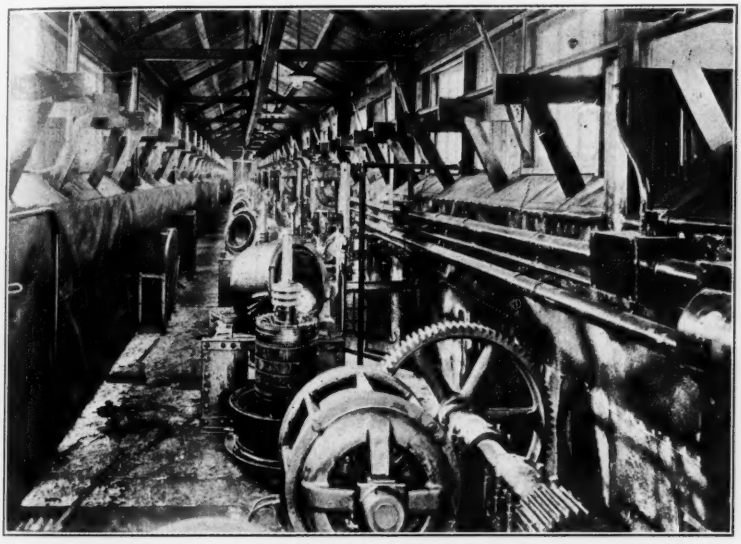
The early years of the manufacture of smokeless powder in this country gave the explosives industry a keen appreciation of the desirability of controlling the viscosity of nitrocellulose used in the manufacture of smokeless powder, especially of powder for military purposes. Nitrocellulose of



HOPEWELL, VIRGINIA, "A" PLANT, FOR THE MANUFACTURE OF GUNCOTTON DURING THE WORLD WAR
E. I. du Pont de Nemours & Company.



HOPEWELL NITRATING HOUSE MECHANICAL DIPPER SYSTEM

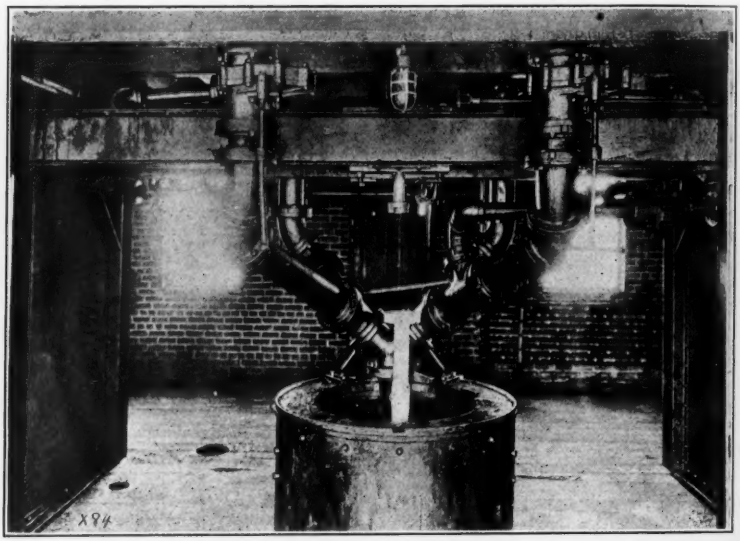


TOP FLOOR OF MECHANICAL DIPPER NITRATING HOUSE SHOWING MOTORS FOR DRIVING THE WRINGERS

HOPEWELL NITRATING HOUSE MECHANICAL DIPPER SYSTEM

varying viscosities requires varying amounts of solvent for the manufacture of powder. This results in some of the powder grains shrinking differently from other grains during the drying of the powder, all of which disturbs the ballistics given by the finished powder. Twenty years ago the largest manufacturers of smokeless powder in this country adopted standard conditions for the purification of linters which, together with standard nitrating conditions and standard stabilizing treatment, produced lots of nitrocellulose sufficiently uniform in viscosity so that the amount of ether-alcohol solvent required for the manufacture of smokeless powder was kept within relatively narrow limits. At that time a reliable method for determining the viscosity of the purified cotton was not available, but from viscosity determinations made on the nitrocellulose, the influence of the temperature, the strength of caustic soda solution, and time of digestion treatment on the viscosity of the cotton and subsequent nitrated cotton were appreciated and the knowledge applied.

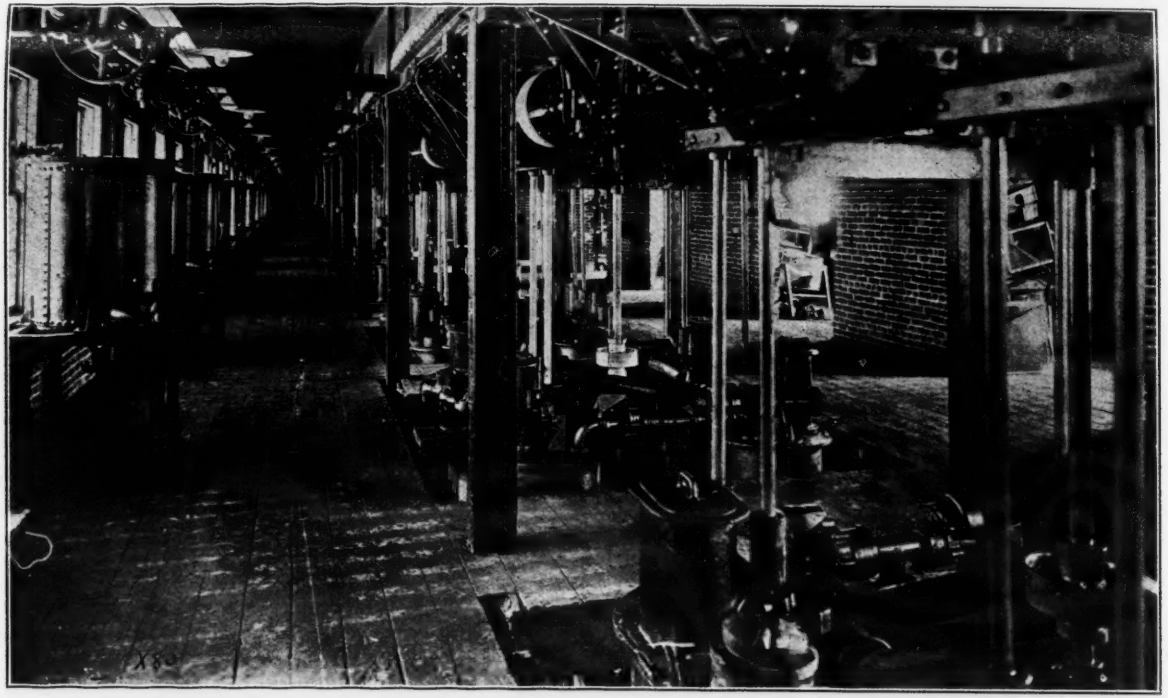
At the outbreak of the World War an enormous plant was built by the du Pont Company at Hopewell, Virginia, with a production of more than 1,000,000 pounds of nitrocellulose per day from a mixture of linters and hull fiber digested under standard conditions. In addition to this the largest outside source of supply was standardized to use similar conditions for the purification of linters. The resulting nitrocellulose was sufficiently



SECOND FLOOR OF MECHANICAL DIPPER NITRATING HOUSE SHOWING CENTRIFUGAL WRINGER FOR REMOVING SPENT ACID FROM THE NITRATED COTTON

uniform in viscosity so that the amount of ether-alcohol solvent required from lot to lot and from plant to plant was for practical purposes substantially the same. All of this materially helped in producing rifle and cannon powder of uniform ballistic qualities. In the case of the manufacture of rifle powders, blends of 45,000 to 50,000 lb. of nitrocellulose were made in order to obtain the advantage of uniformity in viscosity and other qualities.

In the early part of the World War and before our own cotton purification plants could be expanded, considerable difficulty was encountered in the manufacture of certain powders due to the use of nitrocotton made from cotton purchased from outside sources in order to tide over the shortage. This difficulty was recognized as due to the high viscosity of the cotton because of the digestion of the linters at atmospheric pressure. Later in the war a representative of the du Pont Company visited England and found them also experiencing certain difficulties in the manufacture of Cordite, due to the lack of uniform viscosity of the nitrocellulose (*12*). These difficulties led to the adoption of standard conditions for the purification of the cotton used and to the development of a method for determining the viscosity of the cotton in cuprammonium solution. This method is that of Gibson, Spencer, and McCall (*13*) modified by Joyner (*14*), and later modified by J. O. Small of the Hercules Powder Company (*15*).



THIRD FLOOR OF MECHANICAL DIPPER NITRATING HOUSE SHOWING UNITS OF FOUR NITRATING DIPPERS AND ACID MEASURING TANKS

This method with minor changes has been tentatively adopted by the Cellulose Division of the American Chemical Society as the standard method for determining the viscosity of purified cotton (*16*).

Supply of Short Fibered Cotton in United States Proved Just Barely Sufficient for War Requirements

The United States was in the extremely fortunate position during the World War of having within its borders adequate supplies of short-fibered cotton admirably suited for the manufacture of smokeless powder. Even with the increased production in the manufacture of smokeless powder in the latter part of 1918, required by the expansion program which included two additional powder plants (Old Hickory, Tennessee, with a capacity of 900,000 lb. per day and Nitro, West Virginia) it was originally estimated that the short-fibered cotton from the 1918 cotton crop would about meet the increased powder program for 1919. However, in the summer of 1918, owing to the prolonged drought in the cotton belt, it appeared that the supply of linters and hull fiber would be insufficient to cover the 1919 program. It was immediately decided to supplement the supply of short-fibered cotton by using 25% of wood cellulose, preferably sulfite pulp. Large-scale experiments involving the manufacture of over 100,000 lb. of nitrocellulose and smokeless powder from a mixture of 50% cotton and 50% wood pulp had indicated that such a change would not measurably affect either the rate of production or quality of the finished powder. It was proposed to charge the wood pulp into the digesters with the linters and hull fiber and digest with caustic soda solution under standard conditions. This treatment was intended to raise the alpha cellulose of the wood pulp and to thoroughly blend the cotton and wood cellulose fibers (*17*). Only the sudden termination of the war saved King Cotton from sharing his throne with a pretender.

Germany Forced to Nitrate Wood Cellulose during War

In Germany during the war, instead of cotton and cotton rags, wood cellulose was nitrated on a very large scale, and mostly in the form of crêpe paper cut into pieces (*18*). In France, on the other hand, all the nitrocellulose for the manufacture of smokeless powder was made from cotton.

According to Stettbacher (*19*) Germany after the war kept up successfully the preparation of wood pulp and the use of cotton but according to Schwalbe and Schrimpff (*20*) the concurrent use of the two would be continued only if the wood pulp could be purchased at a price which would compensate for the increased expenditure caused by the greater amount of nitric acid used in the nitration.

An article published in Germany since the World War stated that their problem of using wood pulp would have been made very simple if they had

Pressing of Pyro Cannon Powder at Carney's Point du Pont Plant

had available sufficient quantities of cotton to blend with the same. From a source of information which is considered to be reliable, it is understood that in the latter part of the war it became necessary for Germany to lower the velocity requirements of their rifle powder because the wood cellulose could not be nitrated to as high a nitrogen content as cotton.

King Cotton Still Supreme

Since 1919 the explosives industry has been using up the enormous supplies of nitrocellulose left over from the World War. This has now been reduced to a point where increasing amounts of new nitrocellulose are being nitrated daily from purified cotton. It would appear that cotton will continue to remain the standard source of cellulose for making military if not sporting powders as well. While great advances have been made during the past ten years in the quality and suitability of wood cellulose for nitrating purposes, this improvement in quality is of more immediate interest to the lacquer and plastic industry than to the explosives industry. Military powders manufactured during peacetime for war reserves must possess chemical stability of a high order, so that the powder will be available for use after long years of storage. The chemical stability of military powders made from cotton has been established by years of storage, and this has established a certain amount of confidence in its keeping qualities. Powders made from nitrocellulose prepared from wood cellulose must establish similar confidence by satisfactory stability records under varying conditions of storage.

Improved military powders which have been developed in this country since the war have all had for their base nitrocellulose made from cotton.

Millions of pounds of powder which have become obsolete have been reworked to recover the nitrocellulose base and convert it into forms suitable for use in the manufacture of leather substitutes and protective lacquer finishes. Having served its purpose of protecting the American people in war, it now serves to protect their automobiles, furniture, and numerous other articles of daily peacetime use.

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(14) R. A. JOYNER, *Ibid.*, **121**, 1511 (1922).
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(17) R. G. WOODBRIDGE, *Ind. Eng. Chem.*, **12**, 380 (1920).
(18) A. SCHRIMPFF, *Z. ges. Schiess- Sprengstoffw.*, **14**, 185 (1919).
(19) A. STETTBACHER, *Chem.-Ztg.*, **49**, 642 (1925).
(20) SCHWALBE and SCHRIMPFF, *Ibid.*, as (18), p. 41.

Atomic "Numbers" Replacing "Weights." A new system of atomic relations in the known elements has been formulated as a result of recent discoveries regarding the structure of atoms. In a Research Narrative issued by the Engineering Foundation, Dr. Arthur A. Noyes, Director of the Gates Chemical Laboratory, California Institute of Technology, says that atomic "numbers" have replaced atomic "weights" as the basis for the latest periodic charts and tables of the elements.

"It was only about a century and a half ago," according to Dr. Noyes, "that, largely through the researches of Lavoisier, the true nature of the more important elements of which all material things consist was established. Scientists have recently concluded from the study of the structure of the atom that the total number of elements in the universe is probably ninety-two. Of these, eighty-nine or perhaps ninety are now known. Half a century ago about twenty of these, including the radioactive elements, the inert gases, and several of the rare-earth elements, were still undiscovered. Chemists were excited near the end of the last century by the discovery of five of the inert elementary gases, helium, argon, neon, krypton, and xenon, and soon after by that of radium and other radioactive elements. As the number of known elements grew, certain relationships in their properties were observed that suggested a natural grouping and a common origin. In 1868 Mendeléeff, the Russian chemist, constructed a chart arranging the then known elements in periods of eight, though at that time there were numerous gaps. This indication of missing elements led to the discovery of a number of them, and the system made possible a remarkably exact prediction of their physical and chemical properties.

"Recent discoveries in regard to the structure of the atom have led to the construction of new periodic charts and tables based on the atomic 'numbers' instead of the atomic 'weights'; and in these charts, moreover, the elements are arranged in two short periods of eight, followed by two long periods of eighteen, then by one of thirty-two elements and finally by an incomplete series of seven elements."—*Chem. Age*

Offer to Davy Faraday Laboratory. The Royal Institution has received and has accepted an offer from the Rockefeller Foundation of £20,000 for the endowment of research in the Davy Faraday Laboratory. It is stipulated, however, that the sum of £50,000 for the same purpose be secured by the Royal Institution from other sources before June 30, 1933, with an additional £1000 per annum, up to a total of £3000 for the maintenance of research in the laboratory until the capital payment is made.—*Chem. Age*

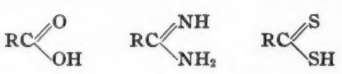
LIQUID AMMONIA AS A SOLVENT AND THE AMMONIA SYSTEM OF COMPOUNDS. VI. ORGANIC AMMONIA COMPOUNDS. PART III. MIXED ACIDS AND THE AMMONIA ACIDS OF NITROGEN[1]

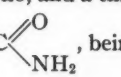
W. Conard Fernelius, The Ohio State University, Columbus, Ohio, and Warren C. Johnson, University of Chicago, Chicago, Illinois

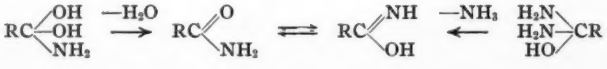
The earlier portions of this paper[2] were concerned with the nitrogen analogs of the familiar oxygen alcohols, aldehydes, carboxylic acid and carbonic acids. There remains to consider certain mixed compounds—derivatives at the same time of water and of ammonia; the disubstituted ammonia derivatives such as benzene sulfonnitramide, $C_6H_5SO_2NHNO_2$; and the ammonia acids of nitrogen.

Mixed Aquo-Ammono Acids

The Carbylic Acids.—In order to have some term at once descriptive of the carboxylic, carbazylic,[3] and similar acids, derivatives of the group $RC\equiv$, Dr. Franklin has suggested "carbylic acid." The substances presented by the following formulas



are, respectively, an aquo, an ammono, and a thio carbylic acid. The acid amides, substances of the type  , being derivatives at the same time of ammonia and water,



may rightly be regarded as mixed aquo-ammono carbylic acids or carboxazylic acids.[4] As acids, the acid amides conduct the electric current and affect indicators when dissolved in liquid ammonia[5] and by their

[1] Previous articles in this series have appeared as follows: I, This Journal, **5**, 664 (June, 1928); II, *Ibid.*, 828 (July, 1928); III, *Ibid.*, **6**, 20 (Jan., 1929); IV, *Ibid.*, 441 (March, 1929); V, *Ibid.*, **7**, 981–99 (May, 1930); VI, Part I, *Ibid.*, 1291–9 (June, 1930); VI, Part II, *Ibid.*, 1602–16 (July, 1930).

[2] (*a*) *Ibid.*, **7**, 981–99 (June, 1930); (*b*) 1602–16 (July, 1930).

[3] Ref. 2*b*, p. 1609.

[4] In the early literature, before the organic side of the ammonia system was adequately developed, the carboxazylic acids were erroneously styled simply ammono acids. See Franklin, *J. Am. Chem. Soc.*, **46**, 2147 (1924).

[5] (*a*) Franklin and Kraus, *Am. Chem. J.*, **23**, 277 (1900); (*b*) *J. Am. Chem. Soc.*, **27**, 191 (1905).

action upon both ammono bases and metals form numerous salts[6,7,8] which conduct the current with a much greater facility than the acids.[9] As carbylic acids these compounds are converted into carboxylic acids and carbazylic acids by hydrolysis and ammonolysis, respectively.

$$RC(=O)OH \rightleftharpoons RC(=O)NH_2 \rightleftharpoons RC(=NH)NH_2$$

The potassium derivative of palmitamide, a mixed aquo ammono soap, behaves like a soap when dissolved in liquid ammonia in that it lowers the surface tension causing foaming.[10] Just as acetonitrile reacts with potassium amide in liquid ammonia to form a salt of a carbazylic acid so acetonitrile reacts with potassium hydroxide in the same solvent to form a salt of a mixed aquo-ammono acetic acid,[11]

$$CH_3CN + KNH_2 \longrightarrow CH_3C(NH)NHK$$
$$CH_3CN + KOH \longrightarrow CH_3CO\cdot NHK$$

The pyrogenic decomposition of the salts of the carboxazylic acids yields methane and sodium cyanate,[10] a salt of a mixed aquo ammono carbonic acid, exactly as salts of the aquo and ammono carbylic acids yield methane together with sodium aquo carbonate and sodium ammono carbonate, respectively.

$$CH_3CONHNa \longrightarrow CH_4 + NaNCO$$
$$CH_3COONa + NaOH \longrightarrow CH_4 + Na_2CO_3$$
$$CH_3CNHNHNa + NaNH_2 \longrightarrow CH_4 + Na_2CN_2 + NH_3$$[12]

Esters of the carboxazylic acids may be either nitrogen or oxygen substituted. In either case ammonolysis of these esters yields the expected substances,

$$CH_3CONHC_6H_5 + NH_3 \longrightarrow CH_3CONH_2 + C_6H_5NH_2$$[13]
$$CH_3C(NH)OC_6H_5 + NH_3 \longrightarrow CH_3C(NH)NH_2 + C_2H_5OH$$[14]

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[6] (*a*) Franklin and Stafford, *Am. Chem. J.*, **28**, 83 (1902); (*b*) Franklin, *8th Int. Cong. App. Chem.*, **6**, 119 (1912); (*c*) *J. Am. Chem. Soc.*, **37**, 2279 (1915).

[7] Numerous salts of ammono and mixed aquo ammono acids that have been prepared, yet in no case (with the single exception of cyanamide and possibly malonamide) has it been possible to replace more than one hydrogen atom of the amino group, $—NH_2$. Thus $RCONH_2$ is a monobasic acid and its salts are binary electrolytes.

[8] It is interesting to note that the mercury and silver salts of the acid amides are stable in water solution. Because of the tenacity with which nitrogen clings to some metals such as silver and mercury, Dr. Franklin has termed these metals "azophiles," lovers of nitrogen.

[9] Smith, *J. Am. Chem. Soc.*, **49**, 2162 (1927).

[10] Fulton (Miss), Dissertation, Stanford University, **1925**.

[11] Cornell, *J. Am. Chem. Soc.*, **50**, 3311 (1928).

[12] *Cf.* Ref. 2*b*, p. 1610. Miss Fulton (Ref. 10) noted that there is also a decomposition of potassium benzamide to nitrile and potassium hydroxide.

[13] Niemann, Thesis, Stanford University, **1926**.

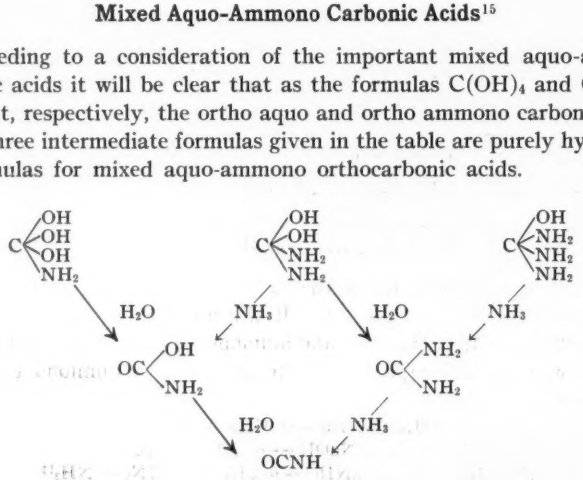
[14] Pinner, *Ber.*, **16**, 1643 (1883).

Furthermore, the acid esters are known to form salts.[6c] Other types of mixed carbylic acids are RCS·OH and RCS·NH_2.

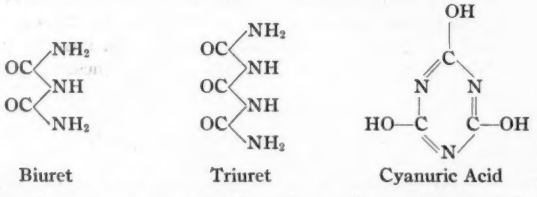
A further type of mixed acid closely related to the carbylic acids is benzene sulfonamide, a mixed aquo ammono benzene sulfonic acid. Numerous salts of acids of this type have been prepared.[6a,c]

Mixed Aquo-Ammono Carbonic Acids[15]

Proceeding to a consideration of the important mixed aquo-ammono carbonic acids it will be clear that as the formulas $C(OH)_4$ and $C(NH_2)_4$ represent, respectively, the ortho aquo and ortho ammono carbonic acids, so the three intermediate formulas given in the table are purely hypothetical formulas for mixed aquo-ammono orthocarbonic acids.



Since dehydration (loss of water) and deammonation (loss of ammonia) are strictly analogous phenomena, it is obvious that the elimination of the elements of water or ammonia or of both water and ammonia from the respective mixed aquo-ammono carbonic acid formulas will yield formulas which will be recognized as those of carbamic acid, urea, and cyanic acid. Furthermore, the strong tendency toward the formation of pyro acids and toward polymerization into six-membered rings gives rise to a large number of other mixed aquo-ammono acids. Biuret, triuret (carbonyl urea), and cyanuric acid are examples of such compounds.



Biuret Triuret Cyanuric Acid

[15] The mixed aquo-ammono carbonic acids are discussed in the following papers where complete references are given: Franklin, *J. Am. Chem. Soc.*, **46**, 2148 (1924); Blair, *Ibid.*, **48**, 87, 96 (1926); Pinck and Blair, *Ibid.*, **49**, 509 (1927).

In support of the view that these substances are mixed aquo-ammono carbonic acids, the following facts are offered: first, carbamic acid and cyanic acid are familiarly known to form salts. In liquid ammonia carbamic acid reacts with an excess of potassium amide to form a dipotassium salt. Second, urea, although too weak an acid to form salts in the presence of water, reacts in liquid ammonia solution with potassium amide to form a mono- and dipotassium salt and also with metallic magnesium to form a magnesium salt. Biuret similarly forms a mono- and tripotassium salt in liquid ammonia and triuret a mono- and tripotassium salt in liquid ammonia and triuret a mono- and dipotassium salt. Third, all of the aquo-ammono carbonic acids mentioned above and numerous others, when heated in water, on the one hand, are hydrolyzed to carbon dioxide and ammonia and, when heated in liquid ammonia, on the other, are ammonolyzed to guanidine. Finally, when fused with an excess of sodium amide these mixed acids are converted into sodium ammono carbonate, sodium cyanamide. Esters of mixed aquo-ammono carbonic acids are saponified to the corresponding alcohols and acids as is illustrated by the ammonolysis of diphenyl urea,[13]

$$OC(NHC_6H_5)_2 + 2NH_3 \longrightarrow 2C_6H_5NH_2 + OC(NH_2)_2.$$

Further Mixed Acids

When acetyl chloride and sodium acetate are permitted to react, acetic anhydride is formed,

$$CH_3COCl + NaOOC{-}CH_3 \longrightarrow NaCl + CH_2CO{-}O{-}COCH_3$$

If sodium nitrate is substituted for sodium acetate, then a substance, acetyl nitrate, is formed which is at the same time the anhydride of acetic and of nitric acids since both of these acids are formed when the anhydride reacts with water,

$$CH_3COCl + NaONO_2 \longrightarrow NaCl + CH_3CO{-}O{-}NO_2$$
$$CH_3CO{-}O{-}NO_2 + H_2O \longrightarrow CH_3COOH + HONO_2.$$

Similarly, acetyl chloride and sodium azide form acetyl azide

$$CH_3COCl + NaNN_2 \longrightarrow CH_3CO{-}N{=}N{\equiv}N + NaCl.$$

This compound, depending upon whether one is considering its reaction with water or with ammonia, may be regarded either as the anhydride of aquo-acetic acid and ammono nitric acid or as the anammonide of mixed aquo-ammono acetic acid and ammono nitric acid,

$$CH_3CO{\cdot}N{=}N{\equiv}N + H_2O \longrightarrow CH_3COOH + HNN_2.$$
$$CH_3CO{\cdot}N{=}N{\equiv}N + NH_3 \longrightarrow CH_3CONH_2 + HNN_2.$$

Consider benzene sulfonylchloride. If it reacts with water benzene sulfonic acid is formed; if it reacts with ammonia benzene sulfonamide is formed.

$$C_6H_5SO_2Cl + 2NH_3 \longrightarrow C_6H_5SO_2NH_2 + NH_4Cl.$$

This latter substance is an acid in liquid ammonia since its solution in that solvent is a good conductor of the electric current.[16] Furthermore, benzene sulfonamide in ammonia solution forms salts with ammono bases[6c] and attacks metals with the evolution of hydrogen gas. It is rightly called a mixed aquo-ammono benzene sulfonic acid. This acid amide reacts with nitric acid to form a derivative known as benzene sulfonnitramide,

$$C_6H_5SO_2NH_2 + HONO_2 \longrightarrow C_6H_5SO_2NH{-}NO_2 + H_2O.$$

This latter substance because of the possession of a replaceable hydrogen atom is still acidic. Such compounds are theoretically impossible of realization among the aquo acids, for obviously the substitution of a second negative group in a molecule of water results not in the formation of an acid but of an acid anhydride. As far as one-half of the molecule, $C_6H_5SO_2NH{-}$, is concerned, benzene sulfonnitramide is a mixed aquo-ammono sulfonic acid; and, as far as the other half is concerned, ${-}NH{-}NO_2$, it is a mixed aquo-ammono nitric acid. Because the acidifying power of two electronegative groups is directed to one hydrogen atom, benzene sulfonnitramide is a very strong acid. Numerous salts of this and other sulfonnitramides have been prepared and found to be stable in water solution.[17]

Other typical representatives of this class of compounds are nitro urea, $NH_2CO{-}NHNO_2$, nitroguanidine, $NH_2C(NH)NHNO_2$, acetyl urea, $CH_3CO{-}NH{-}CONH_2$, barbituric acid, $CH_2\langle{}^{CONH}_{CONH}\rangle CO$, and benzene sulfonochloramide, $C_6H_5SO_2NHCl$ ($-NHCl$ is a residue of ammono hypochlorous acid). Chloramine T, $CH_3C_6H_4SO_2NNaCl$, is the salt of such a mixed acid. There is seemingly no limit to the complexity which this type of mixed anhydride-anammonide may attain. Consider so-called diazoguanidinecyanide, $H_2NC(NH)N{=}N{-}NHCN$, which contains two residues of ammono carbonic acid and one of ammono nitrous acid.[18]

Ammonia Acids of Nitrogen

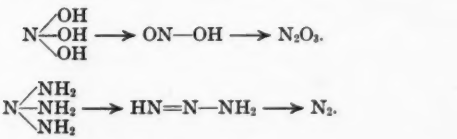
Hydrazoic acid is ammono nitric acid.[19] There are also certain substances which may be regarded as derivatives of ammono nitrous acid. Just as the first scheme below represents the desolvation of an hypothetical aquo nitrous acid so the second depicts the desolvation of a similar ammono nitrous acid,

[16] Ref., *5a;* Franklin, *Z. phys. Chem.*, **69**, 295 (1909).

[17] Mathews, *J. Phys. Chem.*, **24**, 108 (1920).

[18] See below.

[19] Ref. 6*b;* Chuck, Dissertation, Stanford University, **1925;** THIS JOURNAL, 5, 831 (1928).



Here ordinary gaseous nitrogen appears as nitrous anammonide. Diazoaminobenzene, $C_6H_5N{=}N{-}NHC_6H_5$, is perhaps the best known derivative of ammono nitrous acid. That it is an acid ester of ammono nitrous acid is proved by the following experimentally determined facts: first, solutions of this substance in ammonia readily conduct the electric current,[20] and change the color of indicators;[21] second, metallic salts of diazoaminobenzene and similar compounds have been prepared;[22] and, third, diazoaminobenzene is hydrolyzed to an ammono alcohol, an aquo alcohol, and nitrous anammonide,

$$C_6H_5N{=}N{-}NHC_6H_5 + H_2O \longrightarrow C_6H_5NH_2 + C_6H_5OH + N_2.$$

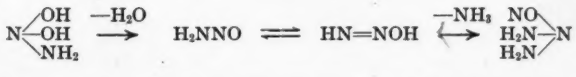
The dinitro substituted diazoaminobenzenes are acids of sufficient strength to decompose alkali carbonates.[23] The relationship existing between ammono nitric acid and ammono nitrous acid is shown by two rather remarkable reactions. First, a very general method for the preparation of diazoamino compounds is afforded by the action of an organic azide on an organomagnesium halide,[24]

$$RN{=}N{\equiv}N + R'MgBr \longrightarrow RN(MgBr)N{=}NR' \longrightarrow RNH{\cdot}N{=}NR'.$$

Second, phenyl azide may be reduced to phenyl triazene, a monophenyl acid ester of ammono nitrous acid,[25]

$$C_6H_5NNN + H_2 \longrightarrow C_6H_5N{:}N{-}NH_2.$$

Finally, there are derivatives of mixed aquo-ammono nitrous acids



such as the nitrosamines, $(C_6H_5)_2NNO$, and benzene diazonium hydroxide, C_6H_5NNOH.

[20] Griswold, Thesis, Stanford University, **1926.**

[21] Fernelius, Thesis, Stanford University, **1927.**

[22] Griess, *Ann.*, **137,** 53 (1886); Beckh and Tafel, *Ber.*, **27,** 2315 (1894); Meunier, *Compt. rend.*, **131,** 50 (1900); Meunier and Rigot, *Bull. soc. chim.*, [3] **23,** 103 (1900); Dimroth, *Ber.*, **39,** 3905 (1906); Ciusa and Pestalozza, *Gazz. chim. ital.*, **41,** I, 395 (1911); ref. 21.

[23] Meldola and Streatfield, *J. Chem. Soc.*, **49,** 627 (1886).

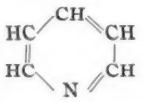
[24] Dimroth, *Ber.*, **36,** 909 (1903); *cf. Ibid.*, **38,** 670 (1905); **39,** 3906 (1906).

[25] Dimroth, *Ibid.*, **40,** 2376 (1907).

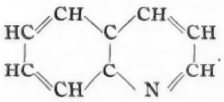
Heterocyclic Compounds of Nitrogen[26]

Not only the chain compounds of nitrogen but also the ring compounds of this element are found to bear very definite relationships to the ammonia system of compounds. A few examples will serve to show the truth of this statement.

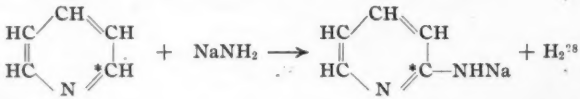
Recalling that substances of the type of benzylidene aniline, C_6H_5-$CH{=}NC_6H_5$, may be regarded as ammono aldehyde-acetals,[27] it would appear that pyridine, quinoline, etc., are cyclic nitrogen compounds of the same type,



and



Numerous reactions of this type of compound support the above view. One very characteristic reaction is sufficient for our present purposes. Whenever such a compound as pyridine, which contains nitrogen doubly bonded to carbon, is heated with sodium amide in boiling benzene or similar solvent there is formed the α-amino compound in an amount varying with the conditions of the experiment and the particular substance used:



Essentially the above equation represents the nitridation[29] of a cyclic ammono aldehyde-acetal to a salt of a cyclic acid ester of a carbazylic[3] acid by means of sodium amide—the carbon atom delectronized is the aldehyde carbon and is marked by an asterisk. Hydrogen, the reduction product, is liberated in an amount corresponding to the nitridation. That α-amino pyridine is a carbazylic acid ester follows from these considerations: by definition, a substance containing the grouping, $RC\begin{matrix}=NH\\ -NH_2\end{matrix}$, is a carbazylic acid and, therefore, a substance of the type, $RC\begin{matrix}=NR'\\ -NH_2\end{matrix}$, is

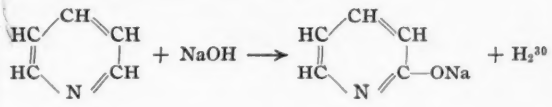
[26] Franklin recently (Columbus Meeting, A. C. S., May, 1929) discussed the relationships of these compounds to the ammonia system. Bergstrom (Pomona Meeting, Pacific Section A. A. A. S., June, 1928; Swampscott Meeting, A. C. S., September, 1928) has shown that pyridine, quinoline, etc., are aldehyde-like compounds of the ammonia system.

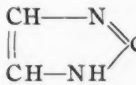
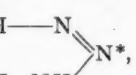
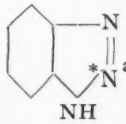
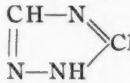
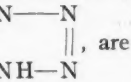
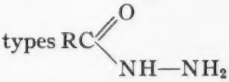
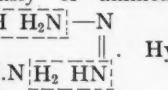
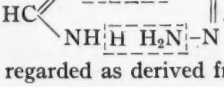
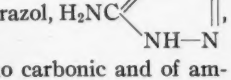
[27] Ref. 2*b*, p. 1602.

[28] Chichibabin and Zeide, *Chem. Abstr.*, **9**, 1901 (1915).

[29] Ref. 2*a*, p. 1236.

an acid ester; that R and R′ happen to be the same group does not alter the relationship. The similar reaction of pyridine with sodium hydroxide gives a salt of a cyclic carboxazylic acid ester:



Imidazol,  , is a cyclic ammono formic acid ester. 1,2,3-Triazol,  , and azimido-benzene,  are acid esters of ammono nitrous acid; the nitrous acid nitrogen is marked by an asterisk. 1,2,4-Triazol,  , and tetrazol,  , are substances of a slightly different character. If substances of the types  and are carboxylic acid hydrazides, then 1,2,4-triazol is a cyclic ammono formic acid hydrazide and tetrazol is a hydrazide simultaneously of ammono formic acid and ammono nitrous acid,  . Hyponitrous acid is a compound of the formula, HON=NOH; accordingly, $H_2N—N=N—NH_2$ is ammono hyponitrous acid.[31] Tetrazol is an acid derived from ammono formic acid and ammono hyponitrous acid,  . Aminotetrazol,  , is similarly to be regarded as derived from ammono carbonic and of ammono hyponitrous acids.[32]

[30] Chichibabin, *Chem. Abstr.*, **19**, 1572 (1925).

[31] The deammonation product of this substance would be or hydrazoic acid (ring formula), a cyclic ammono hyponitrous acid.

[32] Hart [*J. Am. Chem. Soc.*, **50**, 1925 (1928)] has shown that there is an intimate relationship existing between the tetrazols and the acid azides.

Conclusion

This article has attempted to show that many of the organic nitrogen compounds may be regarded as derivatives of ammonia in the same sense that many of the familiar oxygen compounds of carbon may be regarded as derivatives of water (substituted waters). In this connection parallel nitridation and oxidation schemes were developed for the two systems of compounds. Facts supporting the existence of ammono alcohols, ammono aldehydes and ketones, and the ammono carbylic acids, ammono carbonous acid, and ammono carbonic acids have been presented and discussed at some length. There are numerous compounds which belong at the same time to the water and ammonia systems—particularly the mixed aquo-ammono carbylic (carboxazylic) and carbonic acids. Furthermore, there are derivatives of ammonia of the type of benzene sulfonitramide which are impossible of realization among derivatives of water. Finally, the existence of derivatives of ammono nitric and ammono nitrous acids was pointed out. In all, it would seem that the conception of an *ammonia system of compounds* is extremely valuable in classifying a considerable portion of the material of organic chemistry and in predicting properties and reactions of nitrogen compounds.

Many of the facts and interpretations expressed in this paper have not yet found adequate expression in the chemical literature. Professor Franklin has frequently discussed the broader aspects of the organic side of the ammonia system but only on two occasions[33] have these remarks been published. The authors' acquaintance with these matters was obtained largely by the association of one of us (W. C. F.) with Dr. Franklin while the former was a student at Stanford University. A forthcoming monograph by Dr. Franklin will discuss in considerable detail all phases of the ammonia system of compounds. The present articles are published with the full knowledge of Dr. Franklin.

[33] Presidential Address, American Chemical Society, 1923 [*J. Am. Chem. Soc.*, **46**, 2137 (1924)] and lecture on Contemporary Developments in Chemistry, Summer Session, 1926, Columbia University [Reactions in Liquid Ammonia, Columbia Univ. Press, New York, 1927].

Aluminum Utensils Safe for Cooking. Research investigations carried out at Yale University by F. P. Underhill and associates seem to prove that there is no deleterious effect on the human system from the use of aluminum cooking vessels or baking powder containing aluminum. It has been found that aluminum is regularly absorbed by the body in small quantities when taken in food, but that the body is likely to take up only a certain amount, after which absorption decreases and the excess is excreted either in the bile or by way of the bladder. Various food substances were examined and it was found that cherries and onions contained the largest amount of aluminum; that lettuce, milk, flour, and liver contained fairly large quantities; and that many other foods contained smaller quantities.—*Ind. Eng. Chem., News Ed.*

THE PEANUT INDUSTRY. V. PEANUT BY-PRODUCTS*

D. F. J. LYNCH, WASHINGTON, D. C.

In a consideration of the utilization of our large peanut crop, the various industrial methods by which the peanut kernel and its products are marketed must not monopolize our attention to the exclusion of any consideration of the other parts of the peanut plant. When the peanut crop is ready for harvesting the farmer has on his hands the problem of disposing of the whole plant. Naturally, he desires to dispose of all parts of the peanut plant, if possible, to the greatest financial advantage to himself. From his experience the farmer knows that he cannot sell all parts of all his crops and from the return he receives for the sale of many of his crops he must deduct a substantial amount to cover his expense in the disposal of crop wastes.

Peanut Vines

Some peanut growers, however, do dispose of the whole peanut plant without even the usual expense of harvesting. This practice, which is general in Georgia, Alabama, and Arkansas, is known as "hogging off." When the peanuts are ripe in the fall the farmer turns his pigs into the peanut fields. By opening up small patches of peanuts through the use of portable fences the whole crop is consumed by the hogs. For some time it has been known that a considerable part of the crop was disposed of in this way but it was not until December 15, 1928,[96] that reliable statistics showed how extensive this method of disposing of the peanut crop really was. About 36–38 per cent of the nation's peanut crop is thus used as hog food. In disposing of his crop in this manner the farmer gets no immediate return but rather reinvests the value of his crop in pork.

In the South the peanut crop is one of the most important crops grown for animal food. It is doubtful if any crop will produce more pounds of pork on an acre of land or produce it at a lower cost per pound.[97] Some peanut growers harvest the peanut vines, allowing the pods to remain in the ground. The vines are cured to produce a good hay which is little inferior to clover hay and then the hogs are turned into the fields to eat the nuts. Hogs fattened exclusively on peanuts, however, do not produce a desirable grade of pork. The meat is soft and the lard has a tendency to be oily.

The whole peanut plant, however, has been proved to be good food for horses and mules, but it is best utilized as hog food. Experiments carried out in hog feeding at the Alabama Experimental Station[98] proved that

* The preceding four papers of this series have appeared in THIS JOURNAL, 7, (1930) as follows: Part I (April); Part II (May); Part III (June); Part IV (July).

[96] "Crop Report of December 15, 1928, Bur. of Agricultural Economics, U. S. Dept. of Agric."

[97] *U. S. Dept. Agric. Yearbook*, **1917**, p. 123.

[98] *Ala. Experiment Sta. Bull.* No. **43.**

peanut pasture was most useful of those pastures customarily used in pig raising. For a balanced ration a smaller amount of grain was needed. Feeding experiments in Arkansas[99] showed that one-quarter of an acre of peanuts will produce 313 pounds of pork in comparison with 109 pounds of pork produced from one-quarter of an acre of corn, and 148 pounds of pork from one-quarter acre of chufas.

Although many farmers dispose of their peanut crops by turning the hogs into the peanut fields, it is often more advantageous to them to harvest and cure the peanuts for sale to the cleaners and the oil mills and then they are confronted with the disposal of the first peanut by-product known as peanut hay. In the harvesting the whole peanut plant is lifted up out of the ground, the loose soil shaken from the pods, and left lying on the surface of the ground for six to seven hours to wilt. Then the whole plant is stacked for curing. Care is necessary in the operation both for the production of good nuts and a good quality of peanut hay. The plants are stacked on seven-foot stakes so that the pods are in the center and the plants do not touch the damp earth. By thus stacking the plants so as to allow an eight-inch opening at the bottom of the pile ventilation up the middle of the stack is obtained for the curing. (See illustrations in Part I, pages 803–4 of April issue.) To protect the stack from rain it is capped with dry grass. It is customary to allow from four to six weeks for the stack to cure.[100]

Peanut Hay

The next step is the separation of the pods from the vines. Today this is accomplished by large picking machines. The vines are dragged over a horizontal frame on which there is a wire netting. The pods are caught in the wire netting and removed while an endless belt conveyor discharges the vines at one end of the large machines. If the curing has been successful and the dirt has been blown off the vines the farmer obtains, besides his unshelled peanuts, in the vines a valuable stock feed which is known as peanut hay.

The amount of peanut hay produced on an acre will vary greatly with the variety of peanut and its cultivation, and the quality of the hay will depend upon the curing. Experiments at the Mississippi Agricultural Experimental Station[101] produced from 1000 to 3000 pounds of peanut hay to the acre. Usually, however, a farmer will obtain two-thirds of a ton of peanut hay to an acre and this by-product is worth about $10.00 to $12.00 a ton.[102] Feeding experiments at the Texas Agricultural Station[103] showed that peanut

[99] *Arkansas Expt. Sta. Bull.* No. **73.**
[100] *U. S. Dept. of Agri. Farmer's Bull.* **1127.**
[101] *Miss. Agric. Exp. Sta. Bull.* No. **130.**
[102] *Peanut Promotor,* **1,** 31–2 (June, 1918).
[103] *Texas Agric. Expt. Sta. Bull.* No. **245.**

LOADING A CAR WITH SLABS OF PEANUT CAKE

hay had a feeding value 28 per cent higher than that of alfalfa and about 90 per cent of the feeding value of wheat bran. There exists a little less digestible protein in peanut hay than in alfalfa but the higher crude fiber content of the alfalfa makes it a less valuable stock food. Peanut hay which, according to trade custom, comprises the entire plant after the removal of the pods has a higher feeding value than timothy and equal to that of red clover. With nearly 2,000,000 acres in this country yearly planted in peanuts the value of the peanut hay crop amounts to about $20,000,000.

Peanut Meal

Practically all of the peanut hay produced in this country is consumed as stock feed on the farms where it is produced or on nearby farms. From the oil mills, however, there comes another large peanut by-product known as peanut cake, in the disposal of which is added a problem of distribution. Like peanut hay this cake is consumed as stock food. Peanut cake, in the form of flat, dense slabs measuring from 30 to 33 inches long, 14 inches wide, and about $^3/_4$ of an inch thick, is the residue remaining in the hydraulic press after the expulsion of the peanut oil. In this dense slab form the cake is shipped to various parts of the country. The cake is run through a breaker and then ground to the consistency of corn meal for use by the manufacturers of prepared stock feeds. The disposal of this by-product was for years a difficult problem for the oil mills. Although tests had proved it to be an excellent stock food it took considerable work to induce cattle men to use it. F. Hein[104] tells us that peanut cake is a source of large amounts of easily assimilable proteins and is adaptable to nearly all classes of animals. Of late years, however, any prejudice of the farmers toward peanut meal has been overcome and in 1924 when there was little crushing done in this country the demand for peanut meal caused the importation of 4,000,000 pounds of this excellent stock food from China, France, and England.

Like other stock feeds peanut meal is usually sold on the basis of its protein content. This commercial meal is customarily available in two grades; one containing 45–46 per cent protein and the other 41–43 per cent protein. The crushing of No. 1 Spanish kernels will produce a cake containing 48–51 per cent protein but enough hulls are usually ground into the meal to lower the protein content to about 45 per cent.[105] Due to its high hysine content peanut meal is a very good feed for animals.[106] Hysine has been shown to be essential to the growth of animals. Their muscle substance contains about 7 per cent hysine. Animal organisms, however, cannot synthesize this essential amino acid and it therefore

[104] *Bull. de l'office Colonial*, **10**, 44–52.
[105] *U. S. Dept. of Agri. Bull.* No. **1401**.
[106] *J. Biol. Chem.*, **30**, 33–9 (1917).

must be supplied in suitable quantity in the ration to insure growth. Wheat and corn contain little hysine and therefore should be supplemented with some food of high hysine content. Peanut meal is one of the cheapest of animal foods, possessing no objectionable properties and animals fed on it thrive and gain rapidly in weight.

Feeding experiments have demonstrated that the meal is superior to whole peanuts as a hog feed. Using the meal the farmer runs no risk of producing soft pork and oily lard. The meal can be fed to cattle in small quantities after milking with no fear of imparting any objectionable flavor to the milk. The Virginia Agricultural Experimental Station has made comprehensive studies of the comparative utilization by dairy cows of the proteins contained in soy-bean meal, cottonseed meal, and peanut meal. By one group of experiments the investigators determined the relation between the total crude protein and the digestible crude protein of the meal to the milk protein produced. By another research the assimilable protein from the meals was compared with the sum of the milk protein, maintenance protein, metabolic feces protein and the body gains and losses. From the determined results it was shown that the relative gross efficiency of the total crude proteins in producing milk were 27.8% for cottonseed meal, 27.9% for soy-bean meal, and 29.6% for peanut meal. Calculated from the digestible crude proteins in the meals the efficiency percentages were 45% for soy-bean meal, 46% for cottonseed meal, and 50% for peanut meal. It took 3.59 pounds of total crude cottonseed meal or soy-bean meal to produce one pound of milk protein, while 3.38 pounds of total crude peanut meal were necessary for the production of a like amount of milk protein.

Investigations instigated due to cases of abortions and poisonings of animals which were eating peanut cake proved that the ill effects were due to the presence of ricin from castor bean cake which had been included in the cattle feed.[107] In all recorded analyses there has been no indication of ricin in peanut cake.[108] As a poultry feed it seems to stimulate egg-laying and has a favorable effect upon the growth of chickens. This later characteristic enables the poultry raiser who uses this feed to put his chickens on the market in a shorter time which is, of course, a direct financial gain to his business. As a stock food peanut meal is a concentrate and must be mixed with other foods to procure a balanced ration. Mixed with cocoanut meal, it has been demonstrated that peanut meal can be advantageously substituted for oats in the feeding of young horses.

When the price of peanut meal was very low it was used in large amounts as a fertilizer. As a fertilizer the cake depends for use upon its nitrogen content, and is sold upon that basis. By analysis high-grade peanut

[107] *Compt. Rend. Acad. Agr. France*, **6**, 449–54.
[108] *Z. Offentl. Chem.*, **13**, 246–55.

cake contains enough nitrogen to yield 9 per cent of ammonia. This yield of ammonia places peanut meal above cottonseed meal as a fertilizer. In addition to the desirable ammonia, peanut meal also contains small amounts of available phosphoric acid and soluble potash. The high food value of peanut meal, however, makes its use as a fertilizer uneconomical.

Peanut Hulls

There exists, however, another by-product in the peanut industries, the disposal of which is a more serious problem. At the peanut-shelling plants throughout the country are accumulated yearly large amounts of peanut hulls. To find some profitable use for this agricultural waste many of those interested in the peanut industries are now devoting their time and energy. Recently,[109] the peanut-shelling industry reported that there were produced in the year 1927–28, in the Virginia-North Carolina section, 102,549,580 pounds of Virginia shelled nuts; in the southeastern section, 39,998,794 pounds of shelled Runners and 133,890,362 pounds of shelled Spanish nuts; and in the southwestern states, 33,214,654 pounds of shelled Spanish nuts. Estimating the kernel to comprise two-thirds of the weight of the Virginia peanut and seventy per cent of the weight of the Spanish variety the peanut-shelling plants of the country during that year had to dispose of some 70,000 tons of this peanut by-product.

Various attempts have been made to dispose of these hulls with some success. Although the hulls contain little food value,[110] the crude fat content totaling only 3 to 4 per cent and the protein content averaging between 6 and 8 per cent, with only 70 per cent of this protein digestible, some hulls have been used as a filler or roughage in cattle feed.[111] Blackstrap molasses is mixed with finely ground peanut hulls to form a cattle feed known as "molasses meal." Ground hulls are also incorporated in some prepared poultry feeds. Although the hulls add nothing to the food value they impart a yellowish color to the product and for this reason there exists some demand for ground hulls in some European countries. Each year also quantities of ground hulls are added to fertilizers as a filler or diluent.[112]

These hulls have a comparatively high fiber content. In 1917 experiments were carried out at the Forest Products Laboratory at Madison, Wisconsin, to determine whether or not peanut hulls could be suitably used in the manufacture of paper board. The most satisfactory boards

[109] *Peanut Circular* No. 507, B. of Agr. Economics, U. S. Dept. of Agr. (March 13, 1929).

[110] C. S. Füch, *Chem.-Ztg.*, **35**, 358–9.

[111] *The Peanut Promoter*, **2**, 28 (April, 1919); **1**, 52 (July, 1918); and 20–1 (Nov., 1926).

[112] *Ibid.*, **1**, 52 (July, 1918).

were made of equal parts of old newspapers and disintegrated peanut hulls. The laboratory expressed the opinion that the results obtained proved that with these materials paper board could be manufactured which equaled many of the grades of chip board or wall board sold to the public. The laboratory thought that with an assured adequate supply of hulls a cheap grade of paper board could be successfully manufactured, thus offering one profitable opportunity for the disposal of the by-product. No known commercial attempt, however, has been made to carry out this suggestion.[113] There, however, was a recent news notice to the effect that the Simmons Co., manufacturers of bedroom furniture and mattresses, was to use a new plastic product called "Zalmite," made from ground peanut hulls, in its manufacture of bedroom furniture.[114] The pulp obtained by the Forest Products Laboratory from peanut hulls was tested by the Bureau of Standards and found to be too weak for paper.[115]

Some attempts have been made to use ground peanut hulls in the preparation of magnesia tiles and plaster. A portion of the sawdust which is customarily mixed with magnesium chloride and magnesium oxide is replaced with ground peanut hulls. In 1922, U. S. Patent 1,436,747 was issued to R. Yamamoto of Japan for a new magnesia plaster which was made in part from ground peanut hulls. Tests were carried out by the Bureau of Standards on samples of fiber concrete which is prepared from gypsum and fiber. These tests proved that samples made with ground peanut hulls were not as strong as those samples made with hardwood chips.[116] Tests made by this same Bureau to ascertain the possibility of substituting peanut hulls for cork board in refrigeration show the hulls to have 70 per cent of the insulating power of cork[117] and to have the added disadvantage of absorbing water.[118]

Some years ago a useful and profitable outlet was found for ground peanut hulls in the tin plate industry. After immersing the steel sheets in molten tin to produce the tin plate, the sheets are quickly dipped in palm oil to prevent oxidation. Rye and wheat middlings are then dusted onto the plate to absorb the palm oil. Ground peanut hulls were found to effectively absorb the palm oil and there existed a considerable demand for ground hulls in this industry.[119] Due to the fact that the peanut matures in the soil some sand is incorporated in the hull and the failure

[113] *U. S. Dept. of Agr. Bull.* **1401.**
[114] *National Nut News*, **3**, No. 10.
[115] *The Peanut Promoter*, **3**, 141 (Dec., 1919).
[116] *Ibid.*, **8**, (Nov., 1925).
[117] *Ibid.*, **3**, 141 (Dec., 1919).
[118] Tests made in the Color and Farm Waste Division, U. S. Dept. of Agr.
[119] *U. S. Dept. of Agr. Bull.* **1401**; *The Peanut Promoter*, **1**, 49 (July, 1918), and **2**, 20–1 (April, 1920).

to remove this sand resulted in the scratching of the tin plate. Today, therefore, this outlet for hulls seems to have been closed.

The incorporation of peanut hulls in some prepared cattle feeds focused the attention of the agricultural experimental stations upon this waste and consequently most of the analytical work on this waste originated in these laboratories. Like many other agricultural wastes peanut hulls are composed chiefly of lignin, pentosans, and cellulose. Lignin is also a by-product encountered in immense quantities in the paper pulp industry. Little is known about this complex substance and for it no commercial use has been devised. From the pentosan content, however, the five-carbon sugar xylose can be easily prepared. S. F. Acree and his coworkers of the Bureau of Standards have perfected the method for the commercial production of xylose from peanut hulls. Uses for the possible large amounts of xylose which can be obtained from peanut hulls and other agricultural wastes must be developed. Work on the preparation of xylotrihydroxy glutaric acid from xylose is being prosecuted by these same investigators.[120] In the production of xylose, peanut hulls encounter competition from other agricultural wastes as, for examples, oat hulls and cottonseed hulls. In comparative experiments on peanut hulls and cottonseed hulls, Fred, Peterson, and Anderson[121] obtained yields of 26.5 per cent reducing sugars from oat hulls and yields of reducing sugars of only 7.6 per cent from peanut hulls. These results, together with the high yields of 38–40 per cent reducing sugars obtained from cottonseed hull bran by K. S. Markley,[122] hold out little hope for the utilization of peanut hulls as a source for this sugar.

There remains the cellulose content. Upon analysis peanut hulls are shown to contain 56–65 per cent crude fiber. The discovery of a cheap method of converting cellulose into sugars would be one of the greatest benefits to agriculture. Perhaps the bacteriologist will discover some microörganisms that will be able to bring about this reaction efficiently. G. Meunier[123] has developed a method and the apparatus for the breaking down of cellulose with hot dilute sulfuric acid under high steam pressure. He claims that lignocelluloses can be degraded as profoundly with his method with dilute acids as is possible with cold, concentrated mineral acids. The advantages of this method are the smaller amount of acid necessary, less time, and the possibility of varying within wide limits the relative and absolute amounts of reducing substances and their products of decomposition by changing the conditions of the reaction. For example, by varying the time of the reaction and the steam pressure the

[120] *Ind. Eng. Chem., News Edition,* **6,** (Nov. 10, 1928).
[121] *Ind. Eng. Chem.,* **15** (1923).
[122] *J. Am. Soc. Agronomy,* **20** (Sept., 1928).
[123] *Compt. Rend.,* **174,** 468–70 (1922); and *Bull. Mat. Grasses,* 1–3 (1926).

sugar obtained from peanut hulls varied from 15.8–21.8 per cent. The other products, acetic acid, furfuraldehyde, crude acetone, varied respectively, 2.26–4.38%; 2.42–2.66%; and 0.15–0.47%. About 1–1.5 per cent of other substances soluble in ether were produced. Meunier claims that the sugar produce is entirely fermentable and the residue consisting of lignin has sufficient heating value to fulfil all the requirements of the process.

With the possibility of finding some use for peanut hulls in the rapidly expanding cellulose industries the Color and Farm Waste Division of the U. S. Dept. of Agriculture made a study of peanut hull cellulose. Using either the soda cook or the sulfate method yields of 40 per cent unbleached cellulose were obtained under optimum conditions from peanut hulls. With the neutral sulfite or Keebra method two per cent higher yields were obtained. This pulp was not hard to bleach consuming about 20 per cent of its dry weight of chlorine. The bleaching loss did not exceed 10 per cent of the weight of the pulp. Yields of bleached pulp therefore averaged 36–38 per cent. This pulp contained 75–78 per cent of alpha cellulose. The pulp fiber is very short and the ash content varies from 1–1.5 per cent.

For utilization in the nitrocellulose or the rayon industry a high alpha cellulose content and a low ash is demanded. It was found by experiment that the ash in peanut hull pulp can be lowered by alternate treatments with very dilute acid and very dilute alkali at room temperature without detrimental effect on the cellulose. In this manner the ash can be brought below 0.3 per cent. The beta and gamma celluloses can be removed by heating the pulp in a 5–7 per cent NaOH solution on a water-bath or by treating the pulp with a cold 8–9 per cent solution of NaOH. By this treatment peanut hull pulp averaging at least 93 per cent alpha cellulose, on the dry basis, can be prepared.

For nitrating purposes however this pulp has too high a soda-soluble content. Celluloses for nitration must contain not more than 3 per cent of soda-soluble material while the samples of peanut hull pulp tested contained 8–18 per cent of soda-soluble material. The commercial article known as alpha cellulose has an ash of 0.4 per cent; alpha-cellulose content of 93 per cent and a soda-soluble content of not over 12 per cent. Peanut hull pulp can be prepared to meet these specifications. Commercial viscose wood pulp contains between 86.5 to 90 per cent alpha cellulose and its soda-soluble material varies from 14 to 22 per cent and therefore peanut hull pulp compares very favorably with this viscose pulp.[124]

As a source of cellulose supplemental to cotton linters and wood pulp peanut hulls must meet the competition of other agricultural waste products. Many wastes which contain a high cellulose content are tropical

[124] "Peanut Hull Cellulose." Paper presented to the Cellulose Division of the A. C. S. at Columbus, May, 1929.

and therefore appear to offer little real competition due to the distance from the present cellulose market. In regard to the other sources of cellulose peanut hulls seem to compare favorably. G. M. Rommel[125] reports a cost of $8.00 a ton for cornstalks with an average 15-mile haul and that straw costs from $7.50–$14.00 a ton. Peanut hulls, with a cellulose content equal to or greater than that of other wastes, are already collected at the peanut-shelling plants and are being burned under the plant boilers. With a fuel value of only $2.00 a ton[126] these hulls can certainly be supplied at the few peanut-shelling centers in this country at a price of from $4.00–$5.00 a ton.

Experimental work shows that peanut hulls contain a large amount of cellulose which can be extracted from the hulls using the common soda, the sulfate, or the neutral sulfite method at a slight expense. The conditions of time, pressure, and concentration of chemicals necessary for the production of good quality pulp are not so drastic as to materially affect the pulp. Although this pulp contains a comparatively high ash, this ash can be simply and inexpensively lowered to 0.3 per cent and from this cellulose a pulp can be produced averaging 93 per cent alpha cellulose and containing not over 12 per cent soda-soluble material. At a few points in this country are collected some 70,000 tons of peanut hulls, which should serve as a supplemental source of cellulose, available at a cost of $4.00–$5.00 a ton.

[125] "Cellulose III," *Ind. Eng. Chem.*, **20**, 716–9 (1928).
[126] *Ind. Eng. Chem., News Edition*, **6** (Nov. 10, 1928).

Rubber in Florida, Hope of Department of Agriculture. Para rubber trees planted by the Department of Agriculture in Florida are making remarkable and encouraging progress, according to a report recently given to the Appropriations Committee of the House by Dr. Karl F. Kellerman, associate chief of the Bureau of Plant Industry.

The oldest trees in the experiment are four years old. The Department has discovered that young rubber trees in such a climate as Florida's must be protected by lattice work. The trees will grow about as well as they do in Haiti, Dr. Kellerman believes. The growth in Haiti is satisfactory, inasmuch as the trees produce as much rubber as they do when grown in the tropics, though they do not seem to be quite as vigorous.

A new type of rubber plant from Madagascar is being grown in the Department greenhouses and in the Southwest, Dr. Kellerman says. It promises to become some day a matter of economic importance. This rubber is known as *Euphorbia intisy*. Growing in its wild state, it formerly produced a superior rubber of the Para type, for which purchasers would pay three or four times as much as they would give for any other rubber.

This rubber plant never was cultivated on plantations and is very rare. The Department has only a dozen living specimens, but is hoping to get more seeds this winter from Madagascar.—*Science Service*

OBJECTIVES OF THE COURSES IN GENERAL CHEMISTRY*

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During the past ten years especially the courses in general chemistry offered in our colleges and universities have been subjected to intense investigation and severe criticism. The attacks on the courses has been in part friendly and just and, unfortunately, in part, unjust and destructive. Among the critics, we find teachers and research workers whose long association with graduate instruction and with students who have had previous scientific training has led them to forget the steps by which one may arrive at the stage of scientific reasoning which they employ. These men are usually out of touch with the recent developments in the elementary courses and are in reality criticizing the courses as they existed many years ago, in the light of the knowledge of today. A second group of critics includes many men of high scholarly attainments, who, nevertheless, have no scientific background. These scholars would set the teacher of elementary general chemistry the stupendous task of training his students in one short academic year, so that they may be able to understand, correlate, and interpret highly specialized scientific work as clearly as does the trained scientist. A third group of critics comprises those teachers, who, devoting their best thought and energy to the work in general chemistry, are thoroughly dissatisfied with the results which they obtain. All of these criticisms, whether friendly or unfriendly, just or unjust, must be taken into account and thoroughly examined by the teacher who is interested in giving his students the material best suited to attain the objects for which the courses stand.

This situation is the result of a large number of factors. During recent years, the developments in chemistry, both industrial and theoretical, have been so rapid that the inevitable tendency on the part of the teacher who is keeping up with his subject is to add more and more to the course, so that many topics which formerly were unknown are now considered to be fundamental. Since the war, the number of students going to college has increased very greatly, and this has resulted in a corresponding increase in the number of students entering courses in chemistry without any particular interest in the subject. Formerly, general chemistry was considered to be merely the beginning course in one's chemical education and no one thought of trying to cover the subject in a one-year course. This is no longer the condition, for, with the great developments of chemical industry and the increasing importance of this science, it is now true that the great majority of the students enrolling for courses in general chemistry have no intention of becoming chemists, but do wish to learn something of the subject. There are also a number of students who have no interest in any of their courses and whose desire is to get through college

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta meeting, April 7–11, 1930.

with the least effort. It does not seem that the latter should be seriously considered in studying the objectives of the courses.

Efforts directed toward the solution of this problem vary from the thoughtfully planned course of those who know the field and visualize the problem to the suggestion of those who, with no particular scientific motive in mind, wish to do something different, merely because it is different. From all of these suggestions progress may be expected because they lead to careful study and to an experimental attack on the problem. Several suggestions for courses designed for the non-scientific student have been discussed in THIS JOURNAL (*1*) (*2*) (*4*) (*6*). The topic "pandemic chemistry" was the subject of a symposium held by this division at the Swampscott meeting of the American Chemical Society. One who has followed this discussion is impressed by the utter lack of agreement among the advocates of these special courses. It would appear that a clear definition of the purpose of such courses is lacking, so that each one has devised a course which differs in content and objectives from those devised by others. There seems to have been agreement on only one point; *viz.*, that the existing courses, which they choose to call traditional courses, are so unsatisfactory that the only hope is to discard all previous experience in this field and make a fresh start.

These suggestions may, however, be grouped into two classes. In one of these, "a series of popular lectures covering the whole field of chemistry" is proposed (*1*). Examination of the list of lecture topics set up shows little, if any, correlation between the one topic and the next in the list. A procedure, such as this, is subject to many objections, of which at least two are serious. All teachers know that the casual student in an elementary course actually learns little by attending a series of popular lectures, but, on the contrary, gains many false impressions and a view of the subject which is so vague and superficial that it means very little to him. Such lectures are interesting, instructive, and valuable for the student who has a sufficient background to understand what the lecturer is talking about. This procedure gives the student no adequate idea of the correlation of scientific phenomena nor of the work of the scientist, because the student lacks the basis for making correlations and visualizing the scientific method. An advocate of this type of course in an unpublished report makes this rather surprising statement: "The general purpose of the course is not so much to teach the facts of chemistry, as to correlate and explain chemical and physical facts and phenomena." Just how the student is to attain this remarkable ability to correlate and explain facts which he does not know in terms of principles which he does not understand, this advocate does not make clear. The writer can see great value to the student from a course of popular lectures covering different aspects of chemistry, following a course or courses in

which the student has already gained some foundation, but little real value when given to students without scientific foundation.

A second suggested solution involves the assumption of different theoretical concepts without adequate factual background. These theories are then to be tested, presumably by seeing how they accord with the facts. Since the theories are constructed to explain the facts, it is not surprising to find that they do this; and the whole procedure is illogical for the beginning student, valuable though it may be for the research worker who already knows the background of the theory. Such a course in reasoning about abstract ideas must inevitably fail to develop an appreciation of scientific procedure for it is not itself an exposition of this procedure. Furthermore, a course, constructed from this point of view, fails to give even a basis for understanding the importance of chemical phenomena in industry and in daily life.

A third suggestion, which has appeared recently (*5*), is to cut the Gordian knot by abolishing the one-year courses in chemistry. This is, of course, the most effective method of disposing of the problem of what to teach in such courses. The construction of courses in general science have interesting possibilities and are being tried and studied by many teachers. Nevertheless, we shall still have the problem of content and method in courses in general chemistry, even though such courses come into existence.

The logical method of attacking a scientific problem involves, first, a careful definition of the purpose of the investigation, and, second, a construction of the procedure by which it is hoped that the objectives may be attained. Kendall (*3*) says, "After all, the primary duty of the teacher, whatever his subject, is to train his students to think for themselves and to reason systematically." If this statement of a teacher's function is accepted, it then follows that one of the objects of a course in chemistry is to use the subject matter of chemistry for this purpose. The development and application of the basic laws and theories of chemistry afford a great opportunity for logical thought and systematic reasoning. The series of popular lectures of the so-called "pandemic courses" are, of necessity, informational in character and place stress on specific fact, descriptive or theoretical, rather than on thoughtful generalization.

Chemistry is an experimental science owing great value in one's cultural education to the insight which it affords into a method of thought known as the scientific method. This method is generally considered to consist in the use of facts acquired by careful observation and interpreted by cautious inference to serve as the basis of scientific laws. These laws lead, in turn, to the development of theories in terms of which the observed facts are interpreted and correlated. The concepts are made the more complete by the introduction of hypotheses and speculations, which may or may not be exact, but are in accord with the facts in so far as these

are known. Such theoretical concepts are useful in that they make it possible to construct a model in terms of which the facts may be visualized. The student should understand that there is a distinction between fact and fancy. Dogmatic statements regarding facts expressed in theories should be avoided. It is believed that this treatment enables the student to acquire some view of the manner in which the science has been developed. Frequent allusions to the historical aspects of the subject aid in creating the proper perspective. The student, at this stage of his work, is usually unable to follow the rigorous mathematical testing of a theory and there is no reason why he should be expected to do this; but he is able to appreciate the logic of the theory, when the presentation is based on a sufficient body of established facts. By gaining an insight into the chemist's view of matter and its changes the student may broaden his intellectual horizon by a new point of view in the study of facts and methods which are peculiar to chemistry.

As a second object, to be considered important in the planning of our courses, a true understanding and appreciation of the significance of chemistry under conditions of modern civilization should be developed as fully as the time devoted to the course permits. To this end, the economic applications of some of the more important substances should be an integral part of the course, and should not be considered as extraneous material inserted merely for the purpose of arousing interest. An appreciation of the applications of chemistry in industry and of its relation to our daily life habits is not acquired by merely reciting a list of uses and quoting figures representing the number of tons of a particular substance consumed for this purpose or that. The applications of chemistry are, after all, applications of the properties and reactions of substances, which suit them to the uses for which they are applied. One intelligently visualizes the economic importance of substances only when one understands the properties and reactions which give them their importance.

A third objective is the correlation of the facts, laws, and theories of chemistry with other sciences and with our ordinary habits of thought. Some of the recent writers, in their efforts to popularize the subject and emphasize the importance of chemistry, give the false impression that practically everything worthwhile in modern life is due to the work of the chemist unaided by any one else. A much saner view is given when we show that most of the great developments are the result of the coöperative endeavors of chemists, physicists, engineers, mathematicians, economists, capitalists, and many others including the unskilled laborers. Overemphasis on the importance of our own subject excites ridicule; but the placing of chemistry in its proper relation affords a true estimate of its great importance.

As a fourth objective, we should inspire our students with a sense of

confidence, not only in the scientist and his work, but also in themselves. The student, who is so overwhelmed with the magnitude of the subject that he never knows when he has mastered a given topic, fails to derive from the course either pleasure or profit. The student, at the beginning of his course in elementary chemistry, is usually embarking on a subject which is entirely new to him, both in content and method. Contrasted with this, in his work in literature he is relatively far advanced when he enters college, for he really began his preparation for literature when he first learned to read. It is, therefore, of fundamental importance, during the first few weeks of the course especially, to make progress very slowly and to deal with simple scientific concepts, starting whenever possible with familiar facts and working out from these to broader and more complete knowledge. A discouraged and demoralized student cannot be expected to grasp difficult concepts. Unless we can, from the very beginning of the course, present the subject in a manner such that the student who is making a serious effort sees his own progress in the mastery of new ideas from day to day, we are doomed to failure. In making this statement, no consideration is to be given to the lazy and indifferent student; but it is maintained that the content of the course must be within the capacity of the student of normal intelligence who is making a conscientious effort. It is relatively unimportant whether we complete some particular syllabus or not, if, by developing the subject somewhat more slowly, we can give our students the consciousness of their own mastery of that portion of the subject which we do cover. Here we run counter to what some one has called "the unconscious pride of scholarship," which leads us to attempt to give our elementary students the point of view of the mature scientist and makes us object to omitting anything. Nevertheless, I advocate cutting ruthlessly the amount of both descriptive and theoretical material which is included in the course. The impossibility of covering the subject was pointed out recently by Stafford (*5*). The obvious conclusion is that we should not attempt to cover the subject; but should select those topics which are essential to the attempt to attain the objectives of the course. The remainder should be omitted entirely. No one attempts to cover all of literature, all of history, all of psychology, all of economics, or all of any other subject in a one-year course; but that does not lead us to argue that one should, therefore, make no effort to gain an appreciation of these subjects.

These objectives may be stated in different words and other subdivisions may be made; but the majority of teachers, it is believed, will agree that these are the chief objectives we are striving to attain. They constitute an ambitious program, very imperfectly realized at present, but far more valuable than the mere preparation for qualitative analysis or the gaining of a smattering of either industrial applications or theoretical considerations.

With these objectives in view, the trend of our courses is toward truly cultural courses for all students, those who expect to become chemists and those who do not. The descriptive facts necessary to serve as the basis of laws and theories, and as the basis of an intelligent discussion of the applications of chemistry, may be most effectively presented, in the opinion of the writer, by adopting a classification based on the behavior of substances rather than on the elements which they contain. A recent writer (*6*) has said: "The presentation of the properties of one element and its compounds after another and the drill on equation writing and problem solving, necessary and desirable though these may be for the student who plans to major in chemistry, have no place in such a cultural course." Few teachers of today will agree that their courses consist merely in "the presentation of the properties of one element and its compounds after another and a drill in equation writing and problem solving." By the adoption of the method of classification mentioned above, a large amount of descriptive material may be omitted from the course, because it is replaced by useful generalizations which render it no longer essential. We may thus avoid the extremes of a course of popular lectures on the one hand and a series of abstract theoretical concepts on the other, and may maintain a sane balance between the various different aspects of the subject. We may employ the accumulated experience of generations of great teachers, modifying it, however, in the light of modern conditions to develop a liberalized course which aims to meet the changing needs of our students.

By adopting a minimum list of topics which we consider fundamental and keeping this requirement to a real minimum, we may insist on a mastery of these topics. This list will of course be supplemented by a large amount of additional material which will be discussed and from which the student will round out his knowledge of the subject. It is thus possible to afford time so that the student who becomes sufficiently interested may do outside reading and study under the guidance of his teacher. A list of such readings may be prepared according to a definite plan so as to furnish material for the student who is primarily interested in the philosophical aspects of the subject, its historical aspects, the theoretical considerations, or the economic applications. By such a scheme we may adapt the course, in so far as possible, to the needs of the individual instead of trying to force the whole class into the common mold of mass education. The requirements of the student planning to major in chemistry may be provided for by introducing a certain amount of flexibility in the work in addition to the minimum requirements. He may not commit to memory so large a body of specific facts as formerly was the case; but he will develop general principles of both theoretical and descriptive nature and, it is believed, will be able to apply the facts which he has

learned. From this procedure, the student will gain a broader point of view and a motivation which will lead to more rapid progress in the subsequent courses than in those cases in which the student may have learned much material of no particular value and may have failed to acquire an idea of logical generalizations and their application.

The actual content of the courses which are best suited to accomplish the results suggested above is not now and never will be worked out so that no difference in opinion remains. The writer does not consider that it is either important or desirable that this should be worked out in exactness of minute detail, because each teacher should choose the material best suited to his individuality and methods. There should, however, be agreement on the fundamental objectives. The more nearly we can approach the attainment of these objectives—an insight into the scientists' view of matter, a true appreciation of the significance of the work of the chemist in our industries and in our daily lives, a correlation of scientific phenomena, and a sense of power on the part of the students in their intellectual development—the more valuable our courses will be to the educated man or woman.

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Isotopes of Nitrogen. The recent discovery of oxygen isotopes of atomic masses 17 and 18, and of a carbon isotope of mass 13 [see *Nature*, **123**, 318 and 831 (Mar. 2 and June 1, 1929), and **124**, 182 (Aug. 3, 1929)], has now been followed up by the announcement by S. M. Naude in the first number of the *Physical Review* for December of the discovery of an isotope of nitrogen of mass 15. If this existed, it should produce some additional band heads near 2156 Å. in the spectrum of nitric oxide, and a search for these indicated that they were actually present, very close to the predicted positions. The bands were examined in absorption, and the possibility that the reputed isotope effect was due to the presence of molecules such as $(NO)_2$ ruled out by the fact that the relative intensity of the various band heads was independent of the pressure of the nitric oxide. Nitric oxide $N^{15}O^{16}$ is about as abundant as nitric oxide $N^{14}O^{18}$. Some very faint absorption lines have also been observed which agree with those calculated for the molecule $N^{16}O^{16}$, but the existence of this third isotope, of atomic mass 16, must still be regarded as uncertain.—*Nature* (London)

WHY TEACH CHEMISTRY?*

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The teaching of general chemistry is now very often conducted without sufficient thought as to objectives. This is made evident in placement tests, the best substitute for entrance examinations, in determining what a student has learned concerning subject matter, procedure and reasoning ability in a specialized field of study.

Herbert Spencer, in arguing for science study in educational programs, was forced to think of fundamental and convincing reasons. Many of these reasons appear to have been forgotten so that a restatement of some of them, interpreted in present-day terms, deserves occasional consideration. Regarding education as an opportunity, nothing more, a general educational program must be based upon the three fundamental features, (1) what is necessary, (2) what is useful, and (3) what is ornamental. Science study, in general, helps one to live a more healthy, happy, and successful life. When properly taught, it furnishes a mental discipline equal to that of the grammar of the classics. The study of things is more interesting to the average student than is a study of words, especially to our modern young people of secondary-school age. Scientific chemical facts are unchangeable and are based upon simple, direct, and exact experimental evidence. In contrast, personal opinion is changing ever faster, and the number of personal opinions on any topic, at the present time, defies the making of reasonable laws for the government of the conduct of individual citizens in any one country. Science study, despite its high cost, is increasing, and is of greater value in our every-day life than ever before. Development in science has been so great that facilities for science study seem wonderful when compared to those of a few decades ago. Science training in induction, deduction, and comparison is also necessary for the continuance of our complex civilization with its growing material and energy factors.

Considering the reasons why young men and women undertake the study of chemistry and other subjects, it appears that a very large percentage of them apparently believe that advantages will accrue to them in form of riches, happiness, or success, even if their efforts in such studies are of very low degree. Analyzing the benefits the study of chemistry can confer upon those who apply themselves, we have: (*a*) facts largely illustrated by student experimentation, (*b*) use of the hands and the mind, (*c*) acquisition of knowledge of increasing value in this chemical-electrical age, (*d*) development of inductive and deductive reasoning, (*e*) knowledge permitting efficient utilization of material property, (*f*) knowledge not readily obtained from books alone or in later life when laboratory facilities are not available, (*g*) knowledge concerning human activities in many

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta meeting, April 7–11, 1930.

lines such as industry, agriculture, health and disease, enrichment of life, warfare, and in the modern home, (*h*) influence of heredity on future generations, and (*i*) the supplying of better qualified teachers to continue and develop the teaching of chemistry.

Imagination is a human asset and it is generally admitted that science study stimulates the imagination. A brief review of the subjects appearing in popular scientific journals shows the use of the imagination in a very large number of fields, with opportunities for its increasing use as the field of activities expands. The imagination of Jules Verne as to submarine activities is an example of a vivid imagination reasonably controlled by previous science study.

Science study in general and chemistry study in particular, when taught in a way which approaches its possibilities, can be regarded as furnishing training in observation, knowledge making, imagination, judgment, and in self-elimination. The dogmas of Aristotle regarding matter will not be regarded highly by the modern boy or girl who has worked diligently and completed a course in general chemistry.

The teaching of chemistry to the average class of young people is a large-sized task. This is admitted by all chemistry teachers who conscientiously examine enough of their pupils' note-writing to know what it is like, and who have some regard for order and technic. Yet the writer doubts the value of student notes very much, when inspecting a large number of secondary-school chemistry notebooks and not finding a single mark made by instructors in a large number of schools. Notebook grading appears to be a rare sort of teaching activity. It is a fact that many teachers feel that receiving credit for but one hour's teaching for two hours' laboratory work is a severe penalty for their having entered the profession. Naturally, they will not increase such a penalty by examining or grading (not correcting) laboratory notes unless forced to. Then, with the additional duties of laboratory maintenance, care of many supplies, maintaining and arranging equipment, etc., I feel that, relatively, we teachers as a group, are doing a better piece of educational work than we receive credit for. We should, therefore, be doing the teaching of chemistry the greatest good, if we obtain universal credit for teaching on a clock-hour basis.

Despite the admitted trivial nature of much chemistry instruction, the writer feels that the student who applies himself and utilizes the opportunities available in an average secondary school or college chemistry course will obtain those benefits which the study of chemistry can confer.

Amount of 1930 Nobel Prizes. The 1930 Nobel Prizes will each amount to £9608, according to a report drawn up by the auditors of the Foundation.—*Chem. Age*

LABORATORY EQUIPMENT AND LABORATORY INSTRUCTION*

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The proper handling of this subject is made difficult by the wealth of material which might be introduced, and, in order to systematize and to properly limit it, I have decided to consider only three main topics. I shall, therefore, deal with laboratory equipment and its relation to laboratory instruction, considering how this affects the students' health, comfort, and efficiency. There is no sharp and absolute demarcation between these.

The two chief laboratory factors, having to do with student health, are light and ventilation. The Hall Laboratory[1] is equipped with unusually large windows with steel frames and sash which, consequently, give a maximum of daylight at each opening. The artificial light, when needed, is provided by milk-glass enclosed lamps, and while the amount of light is ample, glare is eliminated. Eye strain and consequent headache may be avoided by these means. In all the balance rooms, the lighting is of the indirect, cove type which produces a minimum of shadows. This requires more electrical energy than some other types of illumination, but we firmly believe "the game is worth the candle" and the use of the balances without undue eye strain is very materially helped by this even lighting.

While the ventilation in these laboratories is not supposed to depend upon the use of the windows, it is, nevertheless, possible to open our windows full length and thus, in unusual circumstances, to permit an inrush of large amounts of air or to permit the escape of a cloud of material. Incidentally, the cleaning of the outside of the window panes is made very easy by this type of window. In normal times, the laboratory ventilation is exclusively by means of remotely controlled fans operating through hoods. These are arranged in small banks or as individual units, depending upon the laboratory, and thus when a small section is meeting in a large laboratory, all the fans need not be put in operation, which, of course, reduces the operating expense. The hoods in the elementary laboratory and in the analytical laboratories are of the end desk type with ample provision for the removal of heavy fumes at the desk level and for the elimination of lighter materials and hot gases through openings provided at the top. Great care was taken to provide abundant ventilation and to make certain the complete replacement of the laboratory air at short intervals so that unpleasant odors and noxious fumes do not accumulate about the students at work. For emergency use, such for example as a benzene fire on a student's desk, a push-pull fan, set in the wall and opening directly to the outside air, can be called into use.

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta meeting, April 7–11, 1930.

[1] The real planning of this laboratory was done by Professor Charles R. Hoover.

It is sometimes extremely difficult to ascertain just where matters affecting health are to be dropped and those affecting comfort only or chiefly are to be introduced. Temperature and humidity come in this category. The laboratory temperatures are maintained at a desirable point by drawing all air which passes through them, by means of transoms and louvres in the doors, from the corridors where the temperature is automatically controlled. With plenty of air circulating, as we have it throughout our laboratories, we feel that not only is the laboratory air clean and reasonably evenly tempered, but the humidity is at least generally no worse than that in the air outside the building.

The Army examination somewhat over a decade ago indicated that flat feet were unusually common among Americans, and, therefore, students who may or may not be afflicted in this way should not, we feel, be asked to stand for a period of three or four hours on absolutely unyielding floors. Our laboratories were, therefore, provided with floors of the mastic type which, while not actually soft, are yet more resilient than cement and more easily cared for and cleaned than wood.

In laboratories where men only are to work, it is frequently the custom to rule out stools or chairs on the assumption that he-men can stand without undue strain or discomfort throughout a laboratory period. With us these run for from three to four hours, and occasionally men stay from one to six o'clock. The experience of the author indicates that it is not necessary to deprive men of the ordinary comforts, which persons working under normal laboratory conditions might reasonably utilize, to prove their physical stamina.

Our aisles between desk units are ample in width, 56″, so that the inconspicuous stools which are available here and there in the laboratories may be used by a student, who, for example, will frequently write up a lot of notes while some material is distilling or refluxing, and even though he is comfortable he will not inconvenience the instructor or his neighbors. Nor need he trespass on his fellows' good nature in requesting another to watch his preparation while he himself is writing in the library or in a classroom.

Stooping or bending, though good as exercise, is physically tiring, and in the laboratory is generally to be avoided if possible. Since most of the student work is conducted on top of the desk, after a series of experiments it was decided to have the desks in the Hall Laboratory somewhat higher than those in many other laboratories, and 39″ was decided upon. The student of ordinary height can thus take temperatures handily, read burets easily, and need not stand upon his head to observe a burner operating under a tripod.

If a desk is too wide, the back portion is wasted space; if it is too narrow students on opposite sides of the aisles tend to collide as each stands

away from the desk so that his hands will operate conveniently on it without a too awkward crook of the elbows. Our desks, which are arranged to face each other, have a bank of pipes under a reagent shelf between the two. The width of an individual desk is 2′. All desks are provided with a toe space. This perhaps seems a very minor matter, but students who continually ram their toes into desks which rise vertically from the floor, would, I am sure, feel great relief in standing at a desk in our laboratory. The desk top overhang of an inch is chiefly beneficial to the student worker who stands close to the desk and does not wish to bang his knees into the cupboards. Incidentally, but very practically, this feature keeps spilled liquids out of drawers and cupboards and greatly aids in maintaining the good appearance of the cabinet work. In most of the laboratories, a small coat closet is provided beneath each desk unit of two desks with ample space for the two men who utilize the unit simultaneously. This may seem an insignificant point as far as student comfort is concerned, but when clothing is allowed to lie about on the desk, accidents sooner or later transform wearable garments into material for the junk dealer, and the mental comfort, at least, of the student is not thereby improved. When coats are hung in the common coat room, occasionally a forgetful individual walks away with a coat belonging to another to the decided annoyance, as a rule, of the original owner of the garment. Such incidents are avoided by our cupboard arrangement.

In every laboratory some means is provided for locking up a student's equipment. We are boosters of the combination padlock scheme. The student lockers are equipped with shelves and drawers, and when closed these are entirely covered by a single full-height door. The advantages of the combination padlock arrangement are numerous, and most of them are conducive to a calm state of mind. A student cannot lose or forget his key since he has none. No one can make a copy of it and use the locker as a mine of apparatus for himself for the same very good reason. If a student forgets his combination, the storeroom clerk can readily give it to him. If the evidence seems to indicate that the combination is known to another person, it is a simple matter to provide that locker with a new combination padlock. Since all the locks are numbered and a record of their location is kept in the storeroom, the locks are sent from one laboratory to another in our building, and, over a period of three years, we have had no difficulties with students remembering combinations of definite locks and subsequently discovering them in their new locations and using them improperly.

One of the drawbacks to the common church supper is the sense of lack of space at the table which each individual too frequently experiences. To be crowded in a laboratory likewise greatly inconveniences students. Those persons who are naturally devotees of laboratory sciences and those

who may suddenly become inspired by them will overlook the inconvenience due to crowding, but a very large percentage of the students in elementary science courses, at least, are there to try out the subject and should be made as comfortable as circumstances will reasonably permit in their introductory work. Each of our students has, including his portion of a sink used by two men, a space of nearly 7′. The aisles wherein students work back to back are, as previously stated, nearly 5′ wide. Thus the students may work at their desks without interference with each other, and the instructors may simultaneously walk down the space between men at their desks. This not only makes the laboratory work more comfortable for the students and for the instructors, but also because the instructors can readily get to individuals who may be doing unwise things, it prevents accidents and improves instruction.

No laboratory succeeds in going through an entire year without at least minor accidents such as cuts and small fires. Our storeroom help is instructed in first aid, and it is a laboratory rule that cuts are to be washed out with a disinfectant solution even in relatively minor cases, and if a bandage is necessary that clean gauze be used. Infections are not difficult to acquire, and we feel that it is better to be safe than sorry, and have, therefore, perhaps to an unusual degree, stressed the desirability of prompt and adequate care of cuts. Both our freshmen laboratory and the organic laboratories are provided with shower baths located over the main aisles and operating by means of a lever moved by a stout chain over a small angle of arc. In case of a serious fire on an individual's garments, the shower bath is available to him or to his neighbors if he, himself, is temporarily incapable of clear reasoning. Perhaps some might hesitate to introduce this safety-first measure because of the fear that students will use the apparatus as a means of amusement and for practical joking. The very simple psychological experiment of indicating to the class that this is presumably going to happen with a few over-exuberant spirits and the expectation of the instructor is that if one gets wet another will shortly thereafter be wet has led to what, in my mind, has been a very singular freedom from any annoyance from this source.

Students do not expect accidents to happen in the laboratory, but they know they are liable to happen, and if they know provision has been made for these untoward events, they can devote their mental energies to their experiments without devoting any particular thought to what they might or had better do should certain undesired circumstances arise.

In this day and generation, when Lady Nicotine is so ardently wooed by the majority, the inability to smoke for a period of hours is a very real discomfort to many. We have, therefore, faced the situation with the utmost frankness, which, in my opinion, is generally the proper way to deal with student problems, and have announced that a small recitation

room, not in use in the afternoons when the laboratory sections meet, is available for smoking. Neatness is gained there by providing an abundance of inexpensive, enamelled dishes which serve adequately as ash trays. In this way we have rid the laboratory of over 99%, in my opinion, of the unpleasantness which student smoking formerly introduced. The instructional staff does not have to function in a police capacity and the students are not under the necessity of surreptitiously smoking in the hoods, or in the toilet rooms, or on the porch of the laboratory.

In dealing with the subject of efficiency in the laboratory I have in mind not only the students, but the staff. Our building is so arranged that the students in large classes and large laboratory groups need not go above or below the ground floor. By this arrangement, a minimum of noise and disturbance is caused in other parts of the laboratory. The professors' offices are located on the second floor, not too distant to be readily reached by those who have serious purpose in seeking an instructor, but sufficiently out of sight to be out of mind of those students who may simply be waiting for other students and who are inclined to drop into a professorial office merely to while away the time.

We have made an unusual endeavor at Wesleyan to provide the students with an abundance of materials for their laboratory work. A director of a prominent industrial research laboratory recently emphasized to a group of teachers that the most expensive thing the industrial laboratory dealt with was the time of human beings; that compared with this, apparatus was a relatively insignificant item and should be provided to every reasonable extent. We feel that time ought to be the most precious commodity at the students' disposal. It has been the observation of the writer, verified by numerous conversations with others, that as a rule the small college pays more regard to the human side of its students working in the laboratory than do the universities, and this is not due to more ample funds per student nor to a relatively larger teaching staff in the smaller institutions. The value of student time, at least to himself, is all too frequently ignored by the larger institutions, and, I believe, not to their advantage. I am not, by these comments, inferring that all kinds of expensive apparatus should be made available to inexperienced workers, neither am I minimizing the advantages of building up workable apparatus from relatively simple and commonly available parts. I am merely suggesting a topic which I feel is one that is too frequently neglected and which in no small measure operates against the attractiveness of science courses in the minds of many.

Our student desks are provided with a maximum of eight commodities—hydrogen sulfide, hot water, distilled water, cold water, air, gas, alternating current, and direct current. Hydrogen sulfide is supplied from a tank located in the laboratory attic, and is made available through hard

rubber cocks in each laboratory but not in every case on each desk. Hot water is produced by passing steam through the aspirating side of a common vacuum pump with the channel somewhat enlarged, through which a regulated stream of cold water passes in the normal way. This is a very simple, satisfactory, and inexpensive method of procuring an abundance of hot water for individual student uses. Distilled water is carried to each laboratory, but not always to each desk, in a block tin line from the attic tank which is automatically filled by means of a steam still. Cold water outlets located over the sinks are of the larger gooseneck faucet type, and make for the easy washing of apparatus, especially condensers and burets, and provide an abundance of water with a minimum of splashing. Compressed air and gas are available on all desks as is alternating current. In the elementary laboratory, hydrogen sulfide, distilled water, and direct current are provided on one desk unit only, which is made available to all students. In the laboratories other than the freshman and qualitative, direct and alternating current outlets are provided on each student desk. Each desk is likewise provided with a numbered set of bottles for the more common reagents. The bottles are of uniform design with, of course, the tincture type being used for all liquids and the salt mouth type for solids. I believe it is generally conceded that neatness of surrounding and equipment makes for neatness and efficiency in performance, and we feel that by stressing certain points, such as uniformity of bottles, and having them arranged in an orderly manner, we accomplish more than simply satisfying a possible over-fastidiousness.

All laboratories are provided with trip scales for coarser weighings, and the elementary laboratory has some of the older analytical balances for the use of students doing introductory quantitative work. Whether or not the use of analytical balances and quantitative experiments by freshmen is really being efficient in so far as the subsequently given course in quantitative analysis is concerned, is perhaps a debatable matter which it is not wise to introduce here.

While I have recommended that an abundance of apparatus be made available to students, I also feel that care should be exercised that they should not have their individual desk outfits unduly large. In other words, they should have ready access to the storerooms and prompt service when they appear there. It has been our experience that a minimum of servicing is required for physical chemistry and for the analytical courses, and, as a result, the storerooms are located relatively nearer the elementary and the organic laboratories.

It is the custom in this laboratory to provide each student with a desk check list on which appear the names of all articles with the prices which the students are charged in case of breakage. It has been found that this

is a very helpful feature since formerly they frequently hesitated to procure a piece of apparatus merely because they feared it was expensive; now they know the cost of the article and generally it is not so expensive as they feared. In this way laboratory efficiency is maintained by keeping the carefully planned desk equipment complete. Also unpleasantness is avoided at the time of rendering bills because the student knows or may know how much his breakage will amount to if he cares to keep a record of the stock slips which he, himself, signs at the storeroom.

Student economies have been effected by a rather complete installation of Pyrex glassware for nearly all of the glass apparatus. Although our desk tops are of a stone material, we find that this glassware stands up very satisfactorily, and breakage is never unduly high. We believe that both from the student viewpoint and that of the department, for us to return to the use of a possibly cheaper type of glassware would savor strongly, in the end, of adopting a "penny-wise—pound-foolish" policy. The laboratory is entirely equipped with burners of the Tirrill type which permit a maximum flexibility as far as the flame is concerned. We feel that this choice of burner is a wise one, since, for all elementary use at least, blast lamps are no longer required in addition to the stock burners, as the proper adjustment of the flame, which is very simply accomplished, will give a high and localized heat together with a sufficient volume for all ordinary uses.

We have endeavored to have the desk storage space ample but not wasteful. A freshman has one drawer and, beneath, a cupboard with a shelf. The space is $15' \times 22' \times 31'$, or nearly six cubic feet, while in other courses the storage space for any one man is about double this. Furthermore, we endeavor to avoid having the desks crammed with equipment. We are not converted to the idea of stocking the desk at the beginning of the year with everything that the student will require for his work of the entire course, although we appreciate the efficiency, at least of a sort, that this permits. Each student is provided with a steam-bath which serves a three-fold purpose of steam-bath, water-bath, and pneumatic trough (*1*).

In order that student breakage may be reduced and the desk be free from a clutter, for apparatus used only occasionally or for relatively expensive apparatus used more frequently, a system of temporary orders has been adopted. In the elementary laboratory, retorts and porcelain suction filter funnel outfits come in this category and are not kept in the desks but are signed for at any laboratory period when their use is indicated, and returned at the close of the same period to the general storeroom. By this very simple change in our former procedure, the breakage of retorts has been reduced to an insignificant fraction of the former figure. The loss of porcelain funnels has also been materially

reduced. Students are always surprised at the cost of porcelain ware and are quite willing to sign for the articles at the storeroom rather than keep them in their desks when not in continual use.

In this building, the interiors of the desks for the different courses were designed for each course by the professor in charge. It is, therefore, only to be expected that they have been found to be satisfactory since there has been no change in staff since the laboratory has been put into use. The alberene tops have stood up admirably, and, despite the fact that they have not been oiled or chemically treated, their original fine appearance has been maintained and this, too, without undue expense for cleaning. Oil spots have been found to be easily removed by a little ether, and wiping with a cloth and subsequent rubbing with fine sandpaper removes all trace of the stain. Once a year, during the summer recess, all the desk tops are sandpapered. It is felt that the natural light-color of this desk top material produces a psychological effect which is advantageous and should be utilized, especially since maintenance has been found to be so easy and so inexpensive.

Each desk unit is equipped with valves so that the several commodities can be completely cut off from any one set of desks without disturbing the use of other units in the room. In this way any sudden accident to the equipment which might occur during the laboratory period does not seriously interfere with the work of more than four students, there being a total of four desks in a double unit, and the displaced men can ordinarily be transferred to other desks. While in general the laboratories are equipped with end desk hoods, the organic laboratories are provided with wall hoods since, especially if poisonous materials are to be used, the entire apparatus is in this course placed in the hood. The end desk hoods in the other laboratories, as previously stated, serve two men and are found to be ample to contain the apparatus usually required to be set up in them, and by their ready access aid efficiency by diminishing the circulation of students through the main aisles of the laboratories.

The sets of reagent bottles, which have been referred to, are used in common by four men in the elementary courses and by two men in other courses; there being in each case four sets of bottles to a double desk unit. This, of course, necessitates providing more bottles than does the turn-table arrangement which is used in some laboratories, but it involves very much less equipment than is required where each student is given a set of bottles. Furthermore, the bottles are at all times in sight and the danger of leakage and damage to desks, through fuming and corrosive material, is avoided. This, we believe, is advantageous.

Wastes, both solid and liquid, are disposed of in a semi-cylindrical, lead-coated, perforated sheet iron device which bridges the sink beneath the pipes. One of these, therefore, serves four students simultaneously.

Liquids are drained directly into the sinks, solids are retained and easily removed by the janitor. Fires, due to the accumulation of vapors and combustibles, are practically non-existent, and the janitorial staff rejoices in that sulfuric acid burns on the fingers no longer occur when the waste containers are inverted in emptying. Unsightly jars on the desk tops, in the aisles or under the sinks are likewise eliminated, and the expense, or rather the lack of it, necessitated by the purchase and very rare replacement of these waste disposal articles (one only has been required in three years), is an important feature. Furthermore, their use goes far to reduce the untidiness so frequently evident, or else so arduously combated, when waste jars are placed on the floors, and filter papers, matches, and so forth are cast by busy students in their general direction.

A reasonable knowledge of glass blowing is almost a prerequisite for some chemical work and most certainly aids in building up the efficiency of the student. For this reason in two of our upper class laboratories, we have installed wall tables, not tops of cupboards into which knees would be jammed, especially designed to facilitate working in glass. Having the operator face a wall rather than a window makes the flame more readily visible and thus aids in the work. By making the outfits easily accessible to the students, we find that without a formal course, but with some well-placed advice, nearly all of our graduate students and senior majors become reasonably adept at the art of glass blowing, using handily both soft glass and Pyrex.

No reference to laboratory equipment and laboratory instruction would be complete without mention of the human element. It is our custom to provide a laboratory assistant for approximately each twenty men. These men are graduate students who are, therefore, not so far removed from their own student days that they cannot appreciate the student viewpoint, and yet, under the sympathetic supervision of the staff, are given sufficient responsibility by the instructors so that they learn by teaching, cultivate self-reliance, and have the satisfaction of knowing that they are very real aids to those students who are temporarily, in part at least, in their charge.

Literature Cited

(*1*) C. R. HOOVER, "A Combined Pneumatic Trough, Steam-, and Water-Bath," J. CHEM. EDUC., **6**, 519–20 (Mar., 1929).

Secret Ink. Cobalt chloride is pink when moist and blue when dry. Warming drives out the water so that the writing appears blue. When you blow your breath over this writing, the cobalt chloride absorbs some of the moisture in your breath and turns pink again.—*The Science Classroom*

THE RECLASSIFICATION OF A CHEMISTRY LIBRARY, ACCORDING TO THE LIBRARY OF CONGRESS SYSTEM

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When a chemist goes to a library in search of information he is really entering a rather special "stockroom," in which the reference books and journals correspond to the apparatus and chemicals. They are the instruments and materials of a sort of vicarious experimentation, which is often as suggestive of future investigations as it is economical of needless repetition. To be of the utmost value, the "stock" should be as complete as possible, and all items should be easily accessible with the minimum of searching. However, the library ought to be more than a warehouse for books—it should function as a showroom also, to exhibit its contents for the benefit of persons who may not know precisely what they want or what is to be had.

The following account of the reclassification of the library of the department of chemistry at Cornell University is presented as an example of the method employed and the points considered in bringing a fairly large collection of reference works into a systematic arrangement based on the present and future scope of chemistry. The experience described is exceptional in that it involved the abandonment of the existing system and the establishment of an entirely different one, thus constituting a more severe test of the procedure chosen than if the library had merely "grown up with it."

The library of Cornell University occupies a central building, but certain special divisions are housed in the various colleges and departments. The system of classification in use was originated in the early days of the University, and is peculiar to Cornell. It has become more or less outgrown, and in the case of books on chemistry presented numerous inconsistencies. These would not be serious if books were dealt with only by their catalog numbers, but in a library such as that of the department of chemistry, where the books are mostly used in the stackroom, it is highly important that those on a given topic should be adjacent on the shelves. The existing classification made no provision for many of the modern fields of chemistry and curious discrepancies frequently appeared, especially since it was not administered by persons conversant with the various subdivisions and topics of the science.

As a consequence, the members of the staff and the advanced students of the department of chemistry were seriously handicapped by having always to resort to the catalog when seeking books, and many valuable works were almost unused because they were "buried" among others unrelated to them. The catalog, which properly should serve to group books in classes, was little more than a list of authors and titles.

For the above reasons, and others of less general interest, it was decided to reclassify and rearrange the library. Over 7500 volumes were involved,

including some eighty sets of periodicals. The books were in continual use, and numerous research workers would have been seriously inconvenienced if the library had been closed during the change. The existing classification numbers had to be preserved for purposes of record in the main library, where a duplicate catalog is maintained. No extra staff was available, and expense had to be kept at a minimum. The librarian was not trained in chemistry, but had had some previous experience in the main library.

To meet these restrictions a certain amount of planning was necessary; it was not a simple matter of "shuffling and a new deal."

The system of classification chosen was that used by the Library of Congress. In addition to the fact that it is eventually to be used throughout the university library, it presents a number of distinct advantages:

1. It is an existing system, capable of considerable expansion, and articulated with other fields of knowledge. Its use as such is preferable to the invention of a new system which would of necessity be similar.
2. Fairly complete printed guides for classification are available.
3. Printed cards may be obtained for almost every new book and for most old ones.

The choice of a system was also influenced by the fact that the Library of Congress Classification has been used for a number of years in the library of the Chemists' Club of New York where it has been found satisfactory. Other systems[1] (*1*) might be useful for certain cases, but in the opinion of the writer they are not as convenient for a chemical library.

Of the chief classes of the Library of Congress system, those designated *Q* (pure science) and *T* (technology) will comprise most books and periodicals belonging in a chemical library. These will fall mainly within the sub-classes: *QC*, physics; *QD*, chemistry and crystallography; *QE*, geology and mineralogy; *QH*, microscopy; *QP*, physiology; *QR*, bacteriology; *TD*, sanitary engineering; *TN*, mining, metallurgy, and mineral industries; *TP*, chemical technology; *TS*, manufactures; and *TX*, foods and domestic science. Within these sub-classes the grouping is on a decimal system, general works being placed before special topics. The published classifications (obtainable from the Superintendent of Documents, Washington) indicate the main subdivisions of the various fields which they include, together with numerous topics in each of these. However, the classification as published is not wholly adequate, largely because of the innumerable recent developments in science and its applications. This is to be expected in any system, and fortunately provision has been made for the insertion of numbers or decimals to cover the systematic arrangement of these additional topics. The classification in successful use at the Chemists' Club had been modified somewhat, which

[1] "Dewey decimal" or "Cutter expansive."

QD CHEMISTRY QD

PHYSICAL AND THEORETICAL CHEMISTRY. *"Physico-chemical"*

450 Periodicals, Societies, etc., see QD 1.
453 General works.
454 Elementary works.
456 Methods of experimentation.
457 Laboratory manuals.
458 Calculations.
461 Atomic theory and laws of chemical combination.

ATOMIC WEIGHTS.

463 General.
464 Of individual elements (alphabetically by chemical symbol).

CHEMICAL ELEMENTS.

466 Nature and properties.
467 Classification. Periodic Law, etc.
468 Atomic structure. Isotopes.
469 Radioactivity.
470 Valence.
471 Chemical compounds. Structure and formulas. Isomerism.
473 Physical properties in relation to structure. *E. g.*, Odor.
475 Inorganic compounds.
Alloys, see TN 690, TS 650, TA 490.
477 Acids (General).
481 **Stereochemistry.** *Stereoisomerism.*
499 Miscellaneous speculations. *Theory of chemical reaction.*
501 **Conditions and laws of chemical change.** *Chemical kinetics.*
502 Chemical equilibrium.
503 Chemical affinity.
504 Velocity of reaction.
505 Reactions between gases.
506 Catalysis.
509 Phase rule, etc. *Allotropy. Polymorphism. States of aggregation.*
510 Thermodynamics.
511 **Thermochemistry.**
513 Thermometry and pyrometry.
514 Calorimeters, -metry.
515 Chemistry of high and low temperatures (general).
516 Combustion, flame, explosion.
517 Dissociation.
518 Melting and boiling points. *Tables see* QD 65.
519 Fusion and solidification.
Electric furnace operations, see QD 157, 277.
524 Evaporation.
526 Fractional distillation.
528 Sublimation.
531 Manipulation of gases and vapors.
533 Vapor densities.
534 Critical state. Critical point. Equations of state.
535 Liquefaction of gases.
536 Research at low temperatures.
537 High pressures. Piezo-chemistry.
Theory of solution.
541 General. *cf. QD 561.*
Special topics.
543 Solubility, osmotic pressure, diffusion, etc. *Heat of solution.*
Dictionaries of solubilities in QD 66.
See also QC 183–189.
544 Nature of action of solvents.
545 Freezing points and vapor pressures. Determination of molecular weight.
546 Hydrates and complexes in solution.
547 Non-aqueous solutions.
548 Supersaturated solutions. Crystallization, etc.
549 Colloidal state. Colloidal chemistry.
550 Adsorption. Capillary phenomena. Surface forces.
551 *Electrical properties of colloids.*

FIGURE 1.—A PAGE OF THE LIBRARY OF CONGRESS CLASSIFICATION, SHOWING REVISIONS (*in italics*)

encouraged the present writer to attempt a more extensive revision. Particularly in the field of "physical and theoretical chemistry" was it necessary to insert additional numbers and sub-topics, as shown in Figure 1. The various general divisions of "chemical engineering"—for instance, plant design, unit operations of a physical or chemical character, and chemical properties of materials of construction—were not represented, and certain of the newer chemical industries and products had to be provided for.

Throughout the revision three points were kept in mind:

1. Sub-topics had to be sufficiently definite and explicit so that a person only slightly conversant with the content of the larger divisions of chemistry would be properly guided, and so that the maximum number of books would obviously fall into their proper classes.

2. Numbers had to be provided for important new subdivisions of the fields, so that within them related works would be grouped together, instead of being arranged only by author. Intervening numbers had to be left to provide for future developments in chemistry.

3. These changes had to be made as amplifications rather than alterations of the existing classification, in order to retain its advantages mentioned above.

It was also found convenient to "stretch" the classification somewhat so as to include a few books not on strictly chemical subjects, but nevertheless of interest to chemists and capable of being construed as belonging to various subdivisions of chemistry and entitled to a place in a chemical library.

The alterations and expansions of the original Library of Congress Classification (amounting to about between ten and twenty per cent additional topics) were first worked out on paper, before the actual reclassification was begun. It was hoped that no gaps would be found when the books were actually assigned their respective class numbers, and very few actually did appear. This may perhaps indicate that the revised classification will be adequate for some little time in the future, but although a considerable amount of imagination regarding probable developments of chemistry has been involved, occasionally a new book appears which deals with a novel configuration of knowledge or a new field of discovery, and a place has to be made for it. Numbers for many additional topics are still available, and the classification can of course be expanded indefinitely if a sufficient number of decimal places are introduced.

The first step in the actual transition was the ordering of the printed cards published by the Library of Congress for all books received by it (all copyrighted in the United States since 1898, and numerous others). These cards, a typical one of which is shown in Figure 2, are one of the

great advantages of the Library of Congress system. Not only do they carry full information about the book, for the benefit of the catalog user, but in addition they serve as a useful guide for the librarian. For instance, each of the more important subjects under which the book should be cataloged is shown (*A*, Figure 2). The number which would be assigned to the book in accordance with the original Library of Congress classification usually appears (*B*, Figure 2). The order number, by which the cards are obtained from the Library of Congress, is located in the lower right-hand corner (*C*, Figure 2).

The procedure used in ordering the cards, which was fortunately the simplest one, was made possible by the fact that the Cornell University library is a depository in which a complete set of all the published cards is kept. In small lots, the cards of the old catalog of the chemistry library were taken to the set of Library of Congress cards, and it was ascertained whether printed cards were obtainable to replace them. If so, the order number of the Library of Congress card was copied, and the number of cards necessary to provide one each for the author, title, and the appropriate cross references (as indicated on the card) was noted. The order numbers were arranged according to the form recommended by the Library of Congress, and the cards ordered in lots corresponding to a hundred or more books at a time. If the above procedure is followed, the cost of the cards is 2.5 cents for the first one and 1.5 cents for each duplicate. On the average the cost of cards will be about 5 cents per title.

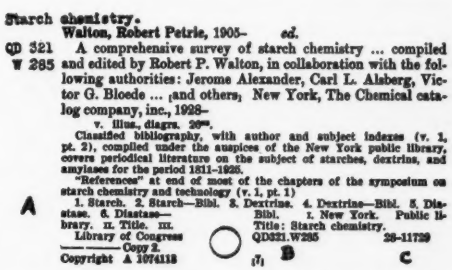
Starch chemistry.
Walton, Robert Petrie, 1905– ed.
QD 321 A comprehensive survey of starch chemistry ... compiled
W 285 and edited by Robert P. Walton, in collaboration with the following authorities: Jerome Alexander, Carl L. Alsberg, Victor G. Bloede ... [and others] New York, The Chemical catalog company, inc., 1928–
v. illus., diagrs. 20cm.
Classified bibliography, with author and subject indexes (v. 1, pt. 2), compiled under the auspices of the New York public library, covers periodical literature on the subject of starches, dextrins, and amylases for the period 1811–1925.
"References" at end of most of the chapters of the symposium on starch chemistry and technology (v. 1, pt. 1)
A 1. Starch. 2. Starch—Bibl. 3. Dextrins. 4. Dextrins—Bibl. 5. Diastase. 6. Diastase—Bibl. I. New York. Public library. II. Title. III. Title: Starch chemistry.
Library of Congress QD321.W285 28-11729
Copy 2.
Copyright A 1074118 [7] B C

FIGURE 2.—A LIBRARY OF CONGRESS CATALOG CARD

As an alternative method of ordering cards by number, if a depository library is not close at hand, the proof sheets used in printing the cards may be employed. Sets of these are sometimes owned by libraries which are not depositories of cards, or the proofs of cards in any class may be purchased fairly cheaply. It is highly desirable to order cards by number, if possible, for mistakes are less likely to occur and there is a considerable saving in the cost of cards because less work is required in filling the order.

If cards or proofs of them are not available for any given book, or if for some reason they cannot be found by the purchaser, orders by author and title are an alternative. In the case of the chemistry library at Cornell as many different cards as possible were ordered by number. Cards for the remaining books were ordered by listing the author, title, and edition

of the book. The cost for such orders is slightly more than 4 cents for the first card and 1.5 cents for each duplicate desired, making the cost per book about 8 cents.

If cards are not obtainable at once, they may be forthcoming later, if the book is a new one or if the Library of Congress happens to be behind in printing cards in that class. Printed cards were ultimately secured for about four-fifths of the books in the library. Of the newer books, and those being received, nearly nine-tenths may be represented by Library of Congress cards.

The ordering of the cards was done by the librarian during lulls in her regular duties. As the cards arrived and accumulated, the writer took the corresponding books from the shelves, examined their tables of contents and method of presentation, if necessary, and assigned to them a class number according to the revised Library of Congress classification, marking it on the inside front cover. Actual inspection of the books was practically essential to satisfactory classification, since titles were often found to be misnomers. As a useful guide to classification, the class number was checked against that printed on the card, when present, by the librarian. The librarian also ascertained the "author number" according to the widely used "Cutter system," and this was added to the class number in the book and on the card.

Journals were classified by subjects, according to the Library of Congress system, and within classes by the Cutter number of the title or society. Serial works, even though under a nominal editorship, were treated as separate books if they were actually independent monographs, provided that they were bound separately. After classification the books were replaced in the stacks.

This work was carried on at odd times, as convenient. It was undoubtedly a great advantage to have it done by a chemist, especially one having the revised classification well in mind and on the lookout for possible shortcomings requiring further revision. However, it should be possible for a non-chemist librarian or one with only an elementary knowledge of the subject to use the revised classification successfully for all but a few books, especially if a chemist were available to advise in doubtful cases. The Library of Congress numbers which appear on most of the printed cards would be a great help, if not followed too rigorously in all cases.

The next stage in the transition was the typing of the proper headings (title, in black; or cross-reference subjects, in red) and the call number (class and author number) on the card, together with any minor revisions as to edition, etc. Cards for the relatively few books for which no printed cards could be obtained were made out on the same general plan as the Library of Congress cards. The number of the cross-reference cards and

the headings on them were determined by the judgment of the librarian, guided by the "secondary entry headings" and the contents as printed on the cards. The cards were then filed in alphabetical order according to their headings. Labels were also pasted on the backs of the books (labels printed with class letters may be purchased) and these were numbered with the new call number. The old labels were not removed. This work was done in spare moments during the librarian's regular hours.

The above operations, which were extended throughout one school year, rendered the library ready for physical rearrangement. This was done after the summer session had ended, at the time when there were relatively few persons using the library. The positions of the volumes on the shelves were of course determined by their call numbers; the books were placed nearest the librarian's desk, since they were called for most by students not having access to the stacks. Spaces for future expansion were left at appropriate intervals; these facilitated the separation of classes, and the placing of little-used books on the upper shelves. As the rearrangement was carried out a few discrepancies of classification were discovered and these were remedied, so that the chief purpose—that of bringing related books together—would be achieved as fully as possible.

The journals presented more of a problem, because of the large number of volumes and the fact that each set had to be considered as a unit. They were arranged in order of their call numbers starting at the inner end of the stacks, so that *Chemical Abstracts* would be adjacent to a large table and could be used with the greatest convenience, without being carried to various parts of the stackroom. The earliest numbers of each periodical were placed highest, as were the little-used journals, but still in accordance to their call numbers. It would be equally possible to intersperse journals among the books, in strict order of the classification, but since this would mean more rehandling with the growth of the library and less ease in finding books without the catalog, it was not deemed preferable.

The rearrangement of the library occupied one person's time for about four days. Books and journals were in use continually throughout the process. As soon as the books were in their places the old catalog was removed and the file of Library of Congress cards replaced it. Guide numbers were placed on the ends of the stacks, as were lists showing the new locations of the journals. The old labels were removed as convenient.

From the first the users of the library have appeared to have very little trouble in finding books without the catalog; the new positions of some of the more familiar journals and handbooks have caused a few moments searching until once located. It is a simple matter for even a stranger to find the general location of books on a given topic, or for the librarian to direct a student to a shelf of books from which he can choose. Neg-

lected books are being used more, new books are more readily noticed, and "browsing" is made more attractive. The librarian is greatly aided in finding and replacing books.

Although these advantages have perhaps tended to lessen the importance of the card catalog, it is nevertheless much more complete and better cross indexed, and as an ultimate means of finding books by author, title, or subject, is a great improvement over the "home-made" cards. When new books are ordered, Library of Congress cards are ordered also; these may not arrive before the book, in which case a temporary card is placed in the catalog.

The cost of the change, carried out as indicated above, was practically confined to cards and labels. The benefits, in saving of time and in facilitating study, cannot be estimated, though they are none the less real. The library as a tool for the investigator is made more familiar and more usable, while the scope and character of its contents are brought to the attention of the student in a direct, vivid, and lasting manner. It is like a museum with open cases, instead of a storeroom with neither order nor convenience.

Literature Cited

(*1*) CRANE & PATTERSON, "The Literature of Chemistry," John Wiley & Sons, Inc., New York City, 1927, pp. 204–6.

Huge Steel Balls to Carry Helium. Six huge steel balls mounted on a flat car to appear on American railroads soon will not be globes consigned to a mammoth pawn shop, but efficient containers for precious helium to carry the gas from Texas oil fields to distant airship hangars.

When tested recently, one of these six-foot spheres, made of steel an inch and a half thick and mounted on a flat car, was filled with helium at 1250 pounds per square inch pressure and run off a 25-foot bank. It was unharmed. It finally exploded under a pressure of 4500 pounds.

The odd-shaped container is used because it can carry twice as much gas as a cylinder of the same volume. That sounds contradictory, but because of its spherical shape, double the pressure in the cylinder is required in the sphere to equally stress the steel. Consequently at double pressure the sphere will hold double volume.—*Science Service*

Zinc Sulfate Kills Weeds but Lets Little Trees Live. Zinc sulfate, sometimes called white vitriol, will kill weeds in a plant bed full of conifer seedlings but will not harm the little trees, Prof. Ferdinand H. Steinmetz and Prof. Fay Hyland, of the University of Maine, have found. They reported their discoveries recently to the American Society of Plant Physiologists at its sixth annual meeting at Des Moines, Iowa.

Eight grams of zinc sulfate, dissolved in sufficient water and sprinkled over a square foot of ground, is most effective, it was learned. Germination of the seeds and growth of the little trees was only slightly reduced by the dose, while practically all of the weeds were killed.—*Science Service*

THE DISPLACEMENT SERIES AS A MEANS OF EFFECTIVE CHEMISTRY TEACHING

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Necessity for Emphasis on General Principles

The chemistry student finds himself confronted with a science covering a field so broad and varied that if, as is frequently done, he tries to conquer it by "brute force" memorizing—repetition alone—he is soon halted. Lost in a maze of chemical reactions and equations, he comes to think of chemistry as "just one crammed thing after another."

The tendencies of recent textbooks do not bring him much relief. Rather are they likely to cloud his thinking. Page after page is devoted to the presentation of the latest discoveries and industrial developments in chemistry—surely a *desirable* objective for the up-to-date student and, without doubt, of great advertising value to the publishers and author. But paragraphs, charts, or schemes for *relating* all this mass of data are conspicuously lacking.

Perhaps this condition is inevitable in the study of chemistry; for this science possesses the alluring quality of never being static, but always advancing to new discoveries and opportunities. Part of the teacher's duty, therefore, is to hold up the ideals of discovery and invention before his students.

To further complicate the situation, the high-school curriculum of today allots very little time to chemistry. So many other studies have crowded in that classroom and preparation hours are approaching the irreducible minimum.

For effective teaching, then, the chemistry teacher is driven to this expedient: to seek out general principles which will *connect* these varied and often newly developed fields into a related scheme. Like the great railroad system which is so located as to speed up transportation, rightly chosen general principles must be so laid down that they lead the student to his objectives in the shortest time.

Special Value of the Displacement Series among General Principles

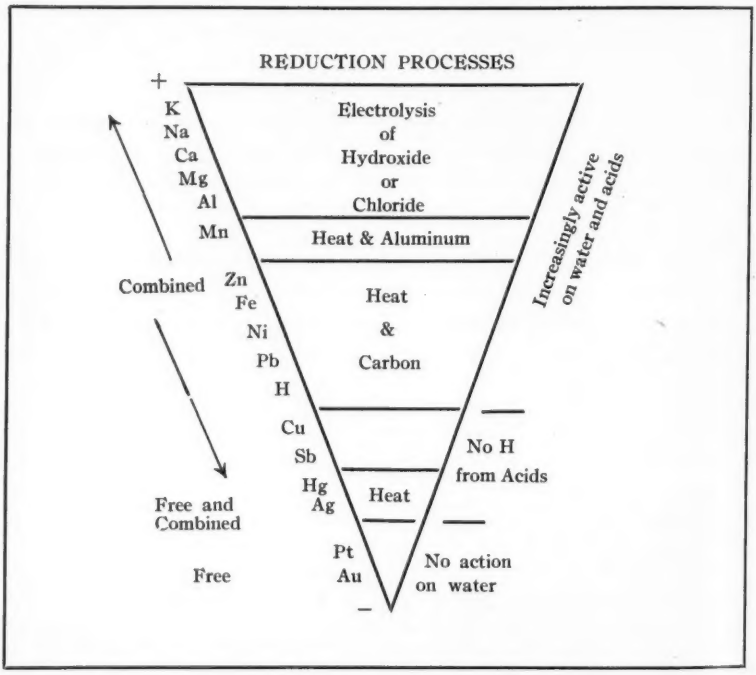
A valuable general principle should be of use throughout the study of the subject. One modern approach to chemistry is by way of the properties of metals—tangible substances. The detailed study of the metals comes late in the course, while that of chemical equations is placed about midway. Consequently, the displacement series is brought in early and as will presently be shown, develops through the entire course.

When to Introduce the Displacement Series

Probably the best time to bring it in is during the study of the preparation of hydrogen; although at the same time it should be correlated to

the study of oxygen, which has already been taken. In this connection it should be brought out that the simple oxides of the more active metals high up in the series (for example, zinc or aluminum oxide) are relatively stable so that oxygen is not easily separated, as is the case with the less active mercury.

Best Form for High-School Use, The Displacement Series Chart



A CONVENIENT CHART FOR CLASSROOM USE

Graphic representations are generally conceded to be of great value in the study of sciences. The student easily remembers and uses the displacement series if he can visualize it in the form of a chart. Such a chart is here shown, used by permission of Mr. C. H. Stone, English High School, Boston. As can readily be seen this chart brings out six important features:

1. Occurrence of the metals
2. Reduction processes
3. Displacement series
4. Relative activity in general
5. Relative activity on water and acids
6. Electromotive series

Only the more important metals are listed on this chart. Further, it is limited to the metals, thus being more easily memorized.

Applications of the Chart. *Preparation of Hydrogen.*—The process of obtaining hydrogen from water by the reducing action of hot iron particles on steam is demonstrated. Questioning brings out the fact that

iron has displaced hydrogen from the vaporized water, heat being necessary. Attention is then called to the chart and it is seen that iron is above hydrogen. The question then comes up whether any other metals above hydrogen will displace it and this leads to the preparation by the action of sodium, potassium, calcium, and finally aluminum (powdered and amalgamated by treating with mercuric chloride). The class then develops the relative activity of these metals and it is seen that the chart sums this up in a graphic manner.

In considering other compounds which contain hydrogen, acids are mentioned. Then the preparation of hydrogen by the action of zinc on sulfuric acid is performed. The residue is saved, set aside, and allowed to concentrate until the crystals of zinc sulfate form. Later, then, the class sees that a replacement of the hydrogen by the zinc has produced a compound of zinc, sulfur, and oxygen quite different from the original acid. Meantime, referring back to the chart, it is found that magnesium, aluminum, and iron are likewise all above hydrogen in the series. Experiment then brings out the fact that they also will displace hydrogen; and that, on the other hand, copper, as would be expected, will not. The question of the best laboratory method for preparing hydrogen is thus found to be a matter of choosing a metal with the right degree of activity; for example, potassium is too violent, while iron is too slow.

Chemical Equations and Valence.—The first three types of equations usually studied are those for: (1) simple decomposition, (2) direct combination or synthesis, (3) simple replacement. Here again the chart is brought out and used by the students to devise equations of these three types. Similarly during the study of valence it again becomes a guide in the drill necessary.

Occurrence of Metals.—Later in the course, when the detailed study of metals is taken, the displacement series chart is very useful. With any given metal, the first step is to note its occurrence. Since the student knows the chart long before this, it requires no effort for him to remember which occur free, free and combined, and combined, respectively. Furthermore, he already knows why potassium, for example, is never found free, while gold is usually mined in that condition; for it is evident that the more active of the series would have combined with some other elements long before the dawn of history.

At this point there is an opportunity to correlate chemistry to history. The metals first used by man were gold and silver. In the bronze age a means of liberating copper had been discovered. Lead, tin, and iron came later. Therefore, it is seen that the series from the bottom up is roughly the historical order of using the metals. The gold-overlaid decorations of the tomb of King Tut and the "cunning worker of metals," Tubal Cain, can also be called to mind.

Relative Activity and Stability of Compounds. Energy.—These subjects are closely linked to the occurrence of the metals. Since the higher in the series the more active the element is, it naturally follows that because more energy was given off in forming the compound, more is going to be required to break it up. On the other hand, relatively inactive metals combining without much evolution of heat should be comparatively easy to separate again. The student will now correlate the study of energy back to the preparation of oxygen and hydrogen, electrolysis of water, sodium chloride, etc.

Reduction Processes for Metals.—The value of the displacement series chart in its particular form is especially apparent at this point. The student finds a great variety of processes employed in freeing the metals from the compounds in which they occur. However, as he takes up the study of the different metals in turn, referring to his chart, he finds it an easy matter to place most of them in four general classes arranged in a logical order. Thus the more active (and consequently more firmly combined) naturally require much energy to separate and therefore are reduced by means of the electrolysis of their hydroxides or chlorides. This is shown very clearly in the upper part of the triangle on the chart.

Next in order comes manganese, which still requires considerable energy. This, the student notes, is provided by the use of heat in combination with the active element, aluminum.

Below manganese in the scale comes a group which are reduced by the action of heat together with the reducing agent, carbon. This group appeals particularly to the mechanically inclined of the class. It is advisable if possible to have the class inspect a foundry. Then later questioning will bring out such points as: the relative amount of energy required to reduce iron and aluminum; that limestone is used as a flux partly because calcium, being more active than iron, more readily combines with the undesirable impurities, thus carrying part of them away in the slag; that a certain amount of manganese is desirable in the cast iron (by virtue of its activity) to tie up with the sulfur remaining, manganese sulfide being mechanically stronger than iron sulfide.

Below this group the student finds the metals mercury, silver, platinum, and gold which are easiest of all to reduce. At this point a discussion of the terms "base" and "noble" metals as used in the middle ages brings out the fact that it was a question of relative activity: "base" metals losing their luster and being converted into oxides when heated, while the "noble" metals were said to "stand the fire test." Thus copper was a "base" and gold a "noble" metal.

Useful Displacement Processes.—Under this heading several examples to be brought out in class at the appropriate times will be very briefly discussed.

DESILVERIZATION OF LEAD BY PARKE'S PROCESS.—Lead ores usually contain silver also. When the molten lead obtained in the process of reduction is treated with a small amount of zinc, an alloy of zinc and silver rises to the top and is skimmed off. Zinc is able to do this because it is more active than lead.

CLEANING SILVERWARE IN THE HOME BY THE ELECTROLYTIC METHOD.—Students are amazed to see the silver come out clean from a solution of sodium carbonate by simply boiling in an aluminum dish. On analyzing the situation, they see that the metallic aluminum forms the negative pole and the silver the positive pole of a small electric cell. The aluminum atoms losing three electrons each go into solution as aluminum ions, Al^{+++}. Then hydrogen is formed at the positive pole as with the voltaic cell. (Hydrogen ions from the solution have gained electrons and so become of zero valence or atomic hydrogen, H°. Having now atoms of hydrogen in the presence of silver sulfide, Ag_2S, and considering our series, it is plain that hydrogen will displace the silver, forming hydrogen sulfide, H_2S, and "free silver" (in the modern sense). Thus it is possible to clean the silver and still have it.

DEVELOPING FILMS AND PAPERS IN PHOTOGRAPHY.—Here, since silver is relatively inactive, the compound of silver and bromine or chlorine is broken up by the developer used, silver being deposited and forming the dark-colored portion of the negative or print as the case may be. For gold-toned prints a second action comes in where the silver displaces the gold from its salt and deposits it on the print.

COPPER-PLATING IRON BY DIPPING IN COPPER SULFATE.—Many students have seen this process used in the shops. For example, where it is desired to lay out the location of holes on a steel plate, the tool maker simply dips it in copper sulfate solution or spreads some of the solution on the plate with a cloth. From the displacement series it is evident that the iron goes into solution, the copper separating out and depositing as a very thin coating. This being soft is easily marked upon with a scriber.

WET AND DRY PRIMARY ELECTRIC CELLS.—In the study of the wet cell, the class develops the fact that the atoms of zinc which are high in the series and therefore possess a considerable tendency to ionize, go into the solution; and that the hydrogen ions, on the other hand, gain electrons and are separated out. Thus they find that the solution becomes zinc sulfate instead of hydrogen sulfate. Similarly in the dry cell the zinc goes into solution displacing the hydrogen and ammonia from the ammonium chloride.

THE SECRET OF GALVANIZED IRON.—At first a class thinks it strange that the active metal zinc is used to protect the less active iron. There are two points to make clear here: (1) the action of the CO_2 in the air results in a thin coating of basic carbonate which resists further action.

(2) Upon the zinc coating being scratched away so that a small amount of the iron is exposed, an electrical action is set up similar to a wet cell. Since zinc is higher in the series it goes into solution, freeing the iron. Thus zinc has been called "the sacrificial metal."

THE CORROSION OF TINNED STEEL OR IRON.—Reasoning backward from the preceding the class brings out the expected action of tin and iron as the opposite of that between zinc and iron. In this case they see that as soon as the surface is scratched the electrical action causes the iron to go into solution instead of the tin, so that the corrosion proceeds rapidly.

COATING OF COMMON PINS WITH TIN.—Sometimes this displacement of tin by iron or brass is an advantage. Brass or iron pins dipped in a solution of a tin salt thus become covered with a very thin coating of tin.

ALUMINUM AS A POWERFUL DISPLACING AGENT. THERMITE PROCESS.—By this time the class is quite well drilled in the use of the displacement series chart. When a possible reducing agent for the oxides of chromium or manganese is asked for, some one is sure to suggest aluminum. It should, however, be brought out that this process is not used where these elements are wanted primarily for alloying with steel, carbon then being substituted. The thermite process provides one of the best demonstration experiments, especially if a steel nail is placed in the bottom of the crucible before the mixture of iron oxide and powdered aluminum is poured in. As the crucible is broken at the end of the demonstration and no nail found, it gives them a concrete illustration of the temperature produced by the displacing action. Of course the practical application of this process to the welding of steel and iron castings, etc., should be clearly developed here.

THE ELECTROMOTIVE SERIES.—During the last part of the study of the metals it is well to bring out the reasoning back of this particular arrangement of elements in terms of the electromotive series. Thus the student is brought to see that the position in the table is an indication of the tendency of the element to form ions in solution. If, then, zinc and copper, for example, are placed in sulfuric acid solution the zinc has the greater tendency to form ions. The results occurring when the tops of the strips are touched have been brought out in the study of wet cells. To that might be now added that the further apart two metals are in this series, the greater the electromotive force set up between them when used in a cell.

Other Applications of the Displacement Series.—Many more applications of the displacement series might be mentioned; but by their very number they might distract us from our aim: *effective* teaching.

For effective teaching of the complex and ever-changing science, chemistry, general principles are necessary tools. Paramount among them stands the displacement series chart, since it is introduced early in the course, used almost constantly throughout, and it provides a ready means for *clearly relating* a big proportion of the practical processes and reactions.

GENERATION OF HYDROGEN SULFIDE*

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Generators may be classified as of three types. In the first a small volume of acid is dropped on a large volume of iron sulfide and exhausted quickly. The solution then goes to waste. Parsons (*7*) has described such a generator for a large laboratory and Watts (*13*) for the use of an individual. Parsons found that 1:8 sulfuric acid gave no crystallization in the bottom of the generator, although some formed on the sulfide. By regulated flow of hydrochloric acid, Mosbacher (*6*) and Huber (*4*) obtained a similar effect. Steele and Denham (*12*) by feeding 1:1 hydrochloric acid on iron sulfide steam-heated to 100° got complete reaction. They prefer hydrochloric acid to sulfuric acid because of the greater solubility of ferrous chloride than of ferrous sulfate. Later (*2*) the apparatus was modified for electrical heating.

The second type is manually operated and uses a relatively large volume of acid. This acid is brought into contact with the iron sulfide or removed from contact by raising or lowering the vessel containing the iron sulfide (*5*) or acid. In a simple form, contact is controlled by using a bottle partially full of iron sulfide, and the balance packed with broken glass. Openings are provided at top and bottom to a tee and the bottle is inverted to stop the reaction (*10*). The design is practical for the small laboratory.

A third type is similar to the second but is automatic. Pressure built up in the apparatus pushes the acid out of contact with the iron sulfide. When this pressure is reduced by withdrawal of gas the acid again comes into contact with the sulfide and generation of gas is resumed. The Kipp apparatus is representative of this type. Rupp (*8*) has described a simplified form in which the acid reservoir is separate from the ferrous sulfide container at a higher level and connected by rubber tubing. Hinds (*3*) has described a generator in which the amount of acid is added according to the volume of gas desired. Excess is stored in a small reservoir to which it is displaced by pressure so that the generator is a combination of the second and third types. A bibliography of apparatus has been published (*9*). For large volumes a modified Ostwald apparatus may be used (*1*).

In order to properly specify the detailed method of operation of an automatic hydrogen sulfide generator it is necessary to know the effects of temperature and concentration of acid on the rate of generation. The variation in quality of ferrous sulfide from different sources and the effect of variation in the ratio of acid to sulfide are also important.

Experimental Method

For small-scale runs sticks of iron sulfide were cut approximately 75 mm. long and 12.5 mm. in diameter. These were selected to be relatively

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta meeting, April 7–11, 1930.

free from "core," although some is always present. The sticks so prepared weighed between 19 and 23 grams each and had calculated surface areas of 1380 to 1600 sq. mm. Those selected for comparative runs always agreed in weight within 5 per cent and in surface area within 10 per cent. Irregularities in the iron sulfide do not justify any attempt at greater accuracy. Details of the exact weights and sizes used have therefore been omitted. For large-scale runs the iron sulfide was taken at random from a large shipment.

Three concentrations of sulfuric acid were used.

Concentrated sulfuric acid by volume approximately, per cent	d^{30}_{20}	*Sulfuric acid by weight, per cent*
6	1.068	9.44
12	1.133	18.71
22	1.238	31.90

In the discussion these are, for convenience, referred to on the volume basis.

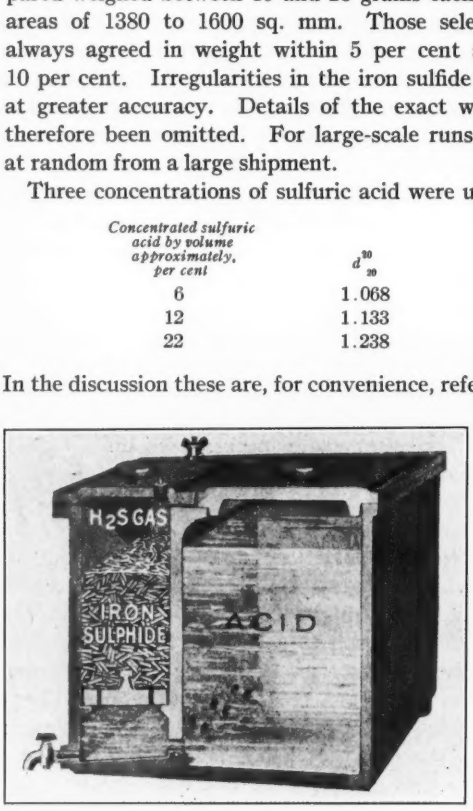

FIGURE 1.—AUTOMATIC STONEWARE GENERATOR

The small runs were made with flasks immersed in a thermostat and the gas collected over high-boiling mineral oil previously saturated with the gas. The larger-scale runs were made with a laboratory stoneware generator of an automatic type, Figure 1, and the rate of flow measured with a flowmeter calibrated with mineral oil as liquid and air as the gas. The variation in viscosity between hydrogen sulfide and air was ignored.

Readings of the small runs were taken at 1-minute intervals for the first 10 minutes, at 2-minute intervals for the next 20 minutes, and at 5-minute intervals for the balance of the time. Readings were taken at 2-minute intervals throughout when using the stoneware generator.

The curves shown are individual runs made after pilot runs had demonstrated that such effects existed. While the absolute values may vary from the average which would be obtained from a large number of runs, they represent a fair picture of what can be expected as relative effects.

Effect of Temperature

In Figure 2 is shown the rate of evolution of hydrogen sulfide from two samples of approximately equal weight and surface area from the same lot of iron sulfide treated with equal volumes of the 12 per cent acid.

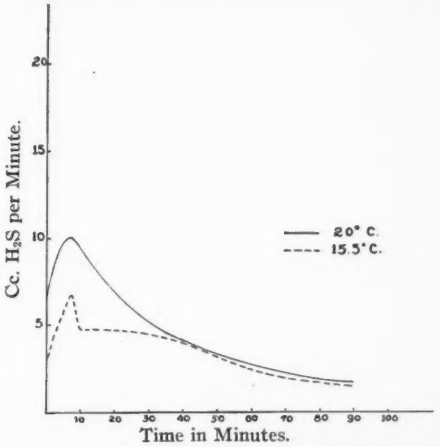

FIGURE 2.—RATE OF GENERATION OF HYDROGEN SULFIDE AT TWO DIFFERENT TEMPERATURES

The initial rate of evolution of hydrogen sulfide is much slower at 15.5° than at 20°, the gas evolved being approximately half as much during the first 15 minutes. With increasing time these two reach very nearly the same rate of evolution, change of acid concentratation offsetting temperature.

The slow initial generation of hydrogen sulfide at the lower temperature is mainly due to the greater solubility of hydrogen sulfide at that temperature. The rate of diffusion of acid to the iron sulfide is an unimportant factor. The necessity of careful temperature control in the additional runs is shown. All further small-scale runs were made at 20°.

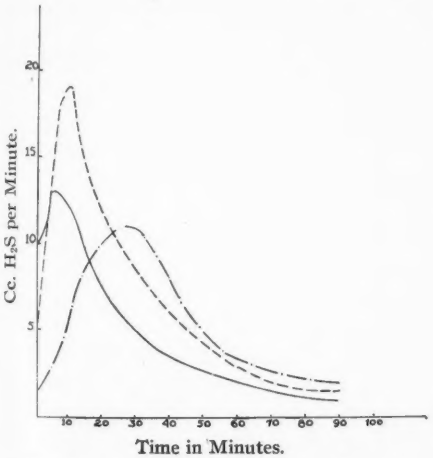

FIGURE 3.—RATE OF GENERATION OF HYDROGEN SULFIDE WITH THREE DIFFERENT STRENGTHS OF SULFURIC ACID

22% by volume —— Specific Gravity 1.238
12% by volume - - - Specific Gravity 1.133
6% by volume — · — Specific Gravity 1.068

Effect of Acid Concentration

In Figure 3 is shown the effect of varying concentration of sulfuric acid. With 6 per cent acid, evolution begins slowly, due to the greater solubility of hydrogen sulfide in dilute acid than in concentrated acid.

FIGURE 4.—RATE OF GENERATION OF HYDROGEN SULFIDE WITH FERROUS SULFIDE FROM THREE DIFFERENT SOURCES

—— Manufacturer A – – – Manufacturer B
— · — Manufacturer C

The eventual condition reached is much the same steady state as with the more concentrated acid solutions. The 12 per cent acid gives the most rapid initial generation of hydrogen sulfide. The 22 per cent acid gives a fairly high initial flow. It drops off very rapidly and it is clear from the curves that the acid is too concentrated. The solubility of ferrous sulfate in water shows that this acid could not approach exhaustion before crystallization of ferrous sulfate would clog the apparatus. Confirming this, crystallization of ferrous sulfate was observed after the test had run overnight.

When a final steady rate of generation is reached it is in inverse order of the concentration of acid used. Since the 22 per cent acid is objectionable because of crystallization of ferrous sulfate and inefficient utilization of acid, the 12 per cent acid is most desirable from these data. A reduction to 10 per cent gives a greater margin of safety against crystallization of ferrous sulfate and is more conveniently prepared. It allows sufficient margin of safety so that a moderate amount of carelessness in preparation will not make the generator ineffective. This concentration of acid is preferable to 6 per cent because of the less frequent filling which will be required.

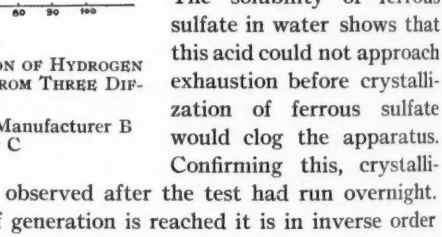

FIGURE 5.—RATE OF GENERATION OF HYDROGEN SULFIDE WITH VARYING RATIOS OF ACID TO SULFIDE

—— Equivalent Amount – – – 25% Excess
— · — 25% Deficiency

Variation in Sulfide from Different Manufacturers

In Figure 4 is shown the rate of generation of hydrogen sulfide with 6 per cent sulfuric acid as used with sulfides from three well-known manufacturers. In Figure III this concentration of acid gave the curve with the broadest peak. This peak also is lower and occurred later with that concentration of acid and may therefore be more easily and more accurately determined. The pieces of sulfide shown in this curve from the different manufacturers were uniform in size and surface area.

When a steady rate of flow is reached one sample is considerably below the other two. The amount of gas evolved in the first 90 minutes is approximately the same for all three samples. The sulfide from Manufacturer C therefore shows a tendency to slower evolution of gas when a steady rate of evolution is reached. This is not serious. From these data the conclusion may be drawn that no gross variation in the quality of sulfide from standard manufacturers is to be anticipated, so far as the rate of evolution of hydrogen sulfide is concerned. The sulfide of Manufacturer C was that used in all other tests.

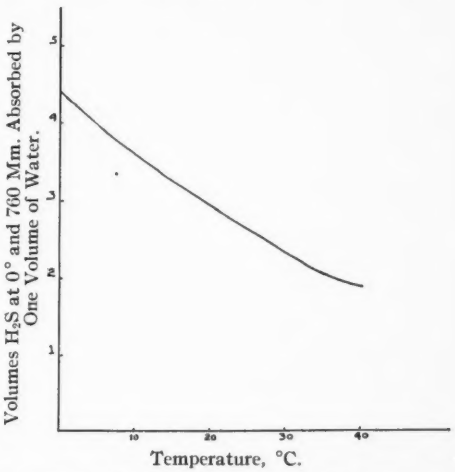

FIGURE 6.—SOLUBILITY OF HYDROGEN SULFIDE IN WATER AT DIFFERENT TEMPERATURES

Ratio of Acid to Sulfide

The amount of acid to react with the standard weight of sulfide was calculated on the assumption that the sticks were 100 per cent ferrous sulfide. Separate experiments showed that the volume of hydrogen sulfide evolved is from 80–100 per cent of the theoretical amount. Runs were then made with the calculated amount of acid, with 25 per cent excess and with 25 per cent deficiency using the 6 per cent acid.

The curves in Figure 5 show that after a steady rate is reached the generation of gas increases as the quantity of iron sulfide relative to the acid is increased. These curves are somewhat irregular due to pitting of the samples used. They indicate that a minimum amount of acid and a maximum amount of iron sulfide are desirable in regular operation. Com-

parison of the curves on small runs and on the large generator leads to the conclusion that to a considerable extent a large amount of iron sulfide relative to the acid can offset a lower temperature of the generator.

Interference of Impurities on Surface

Commercial ferrous sulfide is approximately 70–80 per cent iron sulfide, the balance according to two manufacturers being largely excess iron. Excess sulfur may be present due to incomplete reaction in manufacture.

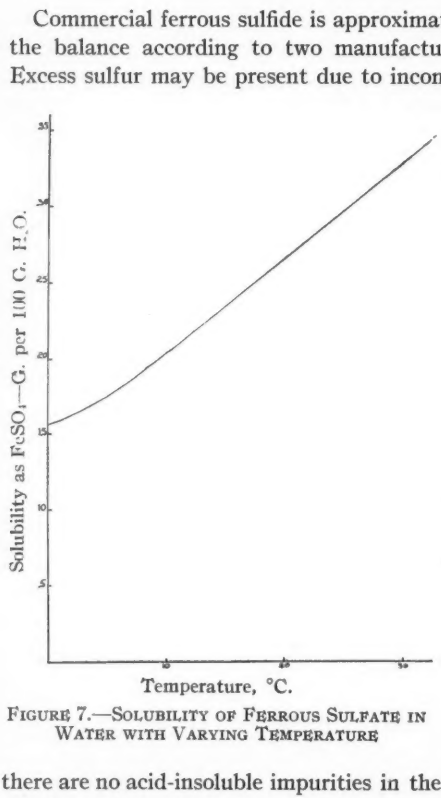

FIGURE 7.—SOLUBILITY OF FERROUS SULFATE IN WATER WITH VARYING TEMPERATURE

A second run was made on one sample with fresh acid. The rate during the first 10 minutes was much less than on the first run with the sample. After ten minutes the curves were practically identical. This indicates that a surface film builds up to a limited extent on the sulfide while standing. This confirms the practical observation that dry used sulfide is at first sluggish in reaction when fresh acid is added. The film referred to is apparently of iron oxide from oxidation of excess iron particles rather than of impurities originally present in the iron sulfide.

After a brief period there was no practical difference in the two runs showing that there are no acid-insoluble impurities in the iron sulfide which cling tenaciously to the surface to prevent reaction.

Solubility of Hydrogen Sulfide and Ferrous Sulfate in Water

The curve of solubility of hydrogen sulfide in water is shown in Figure 6 (*11*). The effect of this solubility in delaying the evolution of gas at low temperatures is clearly shown in Figures 2 and 7. The solubilities are less in dilute sulfuric acid than in water.

The solubility of ferrous sulfate in water is shown in Figure 7 (*11*) in terms of the anhydrous compound.

Runs with Laboratory Generator

A series of runs were made with a laboratory stoneware generator. This apparatus, shown in Figure 1, is an automatic type.

In the first series 3000 grams of stick iron sulfide were used. In the second and third series 6000 grams were used. In each case 14 liters of 12 per cent sulfuric acid were used. The temperature factor was closely observed. The acid was put in when freshly mixed in the first two runs so that the initial temperature was rather high, as would occur in charging the generator under ordinary conditions. The data are given in Figure 8.

In the third run the acid was cooled to 24° before use, corresponding to use of a stock dilute sulfuric acid instead of preparing acid at the time by dilution of the concentrated grade. A lower rate of evolution is shown as might be expected but the difference is not great.

The data show that a generator of this size may be depended upon to deliver over 100 liters of hydrogen sulfide at a rate of 1 liter per minute. After that time the rate of evolution falls off slowly due to partial exhaustion of acid. The generator continues after being shut off for variable periods without any break in the rate of evolution of gas.

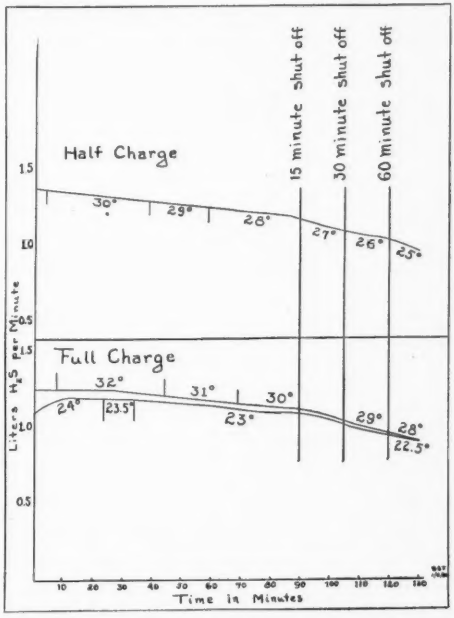

FIGURE 8.—RATE OF FLOW ON LABORATORY GENERATOR WITH 3000 AND 6000 GRAM CHARGES OF IRON SULFIDE AND 14 LITERS SULFURIC ACID SP. G. 1.133

The effect of variable size of the pieces of ferrous sulfide has not been investigated. In the large generator the surface area of coarse stick sulfide is so relatively large as compared with the acid used that no smaller size is required. The data show there is no important lag in the evolution of gas when the initial measurement is made at the end of 2 minutes.

Calculated Conditions of Operation

One of the most important factors in operation of hydrogen sulfide generators is avoiding crystallization of ferrous sulfate. It is desirable to use as concentrated acid as possible without causing such crystallization because of the longer time between fillings with acid which this makes possible. Fortunately, ferrous sulfate forms only one known hydrate in the range of 0 to 50°, and does not form an acid sulfate. The problem is much simplified therefore.

Calculation shows that the 12 per cent acid of specific gravity 1.133 would just give crystallization of ferrous sulfate at 30° if complete conversion to ferrous sulfate occurred. In one case, when the large generator stood over night and the temperature dropped to about 10°, ferrous sulfate deposited in the bottom of the generator. It had been run until the capacity was less than 100 cc. per minute. A corresponding 10 per cent acid would just crystallize at about 20° if complete conversion had occurred. In practical operation, allowing for the incomplete exhaustion obtained, crystallization is certainly not to be expected at room temperature with a 10 per cent acid. If working under conditions of unusually low temperature the concentration permissible would have to be further decreased.

Conclusion

In small runs with uniform weights of sulfide the reduction in the rate of generation of hydrogen sulfide is marked with decrease in temperature. After the first few minutes the rate of generation is greater with more dilute acid, within the limits studied. Convenience dictates the use of as concentrated acid as possible without getting crystallization of ferrous sulfate. Iron sulfide from three manufacturers did not show gross variations in the rate of evolution of gas under the same conditions. As large an amount of iron sulfide as possible should be used if rapid evolution of gas is desired.

In runs with an automatic stoneware generator the above conditions are satisfactorily met by using coarse stick iron sulfide and 10 per cent sulfuric acid by volume at 20° or higher.

Acknowledgment

The results presented in this paper are published by permission of the United States Stoneware Company, Akron, Ohio.

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Origin of Helium-Rich Natural Gas. Helium is remarkable for its unusual facility in diffusing through glass and other materials. Williams and Ferguson have shown that at 500°C. the permeability of quartz-glass to helium is nearly thirty times that to hydrogen. R. C. Wells has pointed out the application of this and similar results to the problem of the origin of helium concentrations in natural gas (*J. Wash. Acad. Sci.*, Sept. 19, **1929**). He writes, "We may suppose that when deeply buried rocks become heated, as they evidently have been during certain geologic epochs in some localities, helium would have a particular and special tendency to escape at one stage of the heating, say 200°, and, if then collected and trapped by overlying impermeable barriers in a cooler environment, would constitute helium-rich gas." Wells directs attention to another process that similarly contributes to helium concentration. He has investigated the diffusion of hydrogen and carbon dioxide through the pores of ball-clay, and finds, in accordance with the principles first established by Graham, that in every mixture the first fraction that passes through is richer in hydrogen than the original mixture. He suggests that it is reasonable to suppose that helium will behave like hydrogen and that the process of diffusion is worthy of consideration as a preferential means of concentrating helium. Thus, for the first time, a reasonably satisfactory explanation is forthcoming for the presence of relatively abundant helium in natural gases from mines, springs, and earth vents generally.—*Nature*

Natural Gas. In the October issue of the *School Science Review*, Mr. J. Kewley, of the Asiatic Petroleum Company, gives an interesting account of natural gas from petroleum wells, which consists essentially of hydrocarbons of the paraffin series, methane predominating. This is produced in enormous amounts, and is not always utilized. At present 32 million cubic feet per day are uselessly burned in Persia. New applications of the gas are, however, being found. In the United States this gas is supplied for heating purposes to industry and for making carbon black, which is obtained by the incomplete combustion of the gas and is used as a pigment and in the manufacture of motor tires. The modern tire contains about 30 per cent of carbon black incorporated with rubber, and this very greatly increases its resistance to wear. Another use of the gas is the extraction of volatile liquid constituents from it for blending with motor spirit. Ten per cent of this now comes from the natural gas. The very volatile constituents are stored in spherical tanks of large capacity, up to 1000 tons, called Horton spheres, and Mr. Kewley states that there is some prospect of the introduction of these tanks into Great Britain for the storage of coal gas under pressure. He considers that there is likely to be a considerable utilization of natural gas in making synthetic chemical products, such as formaldehyde, alcohols, and acetone, for use in the rapidly developing cellulose paint and other industries.—*Nature*

THE BALANCED COLUMN METHOD FOR THE DETERMINATION OF THE DENSITY OF LIQUIDS*

LLEWELLYN HEARD, UNIVERSITY OF GEORGIA, ATHENS, GEORGIA

While generating carbon dioxide by the calcium carbonate-acid method, and thence conveying the gas into a solution to be saturated, it was noticed that the acid medium rose to a considerable height in the thistle tube. The jet, from which the gas was escaping, was withdrawn from the solution and placed in solutions of different densities. In each case a rise of different height occurred in the thistle tube. It thus appeared that the rise in the thistle tube quite likely was a function of the density of the liquid through which the gas was escaping. With this thought in mind the following described apparatus was developed:

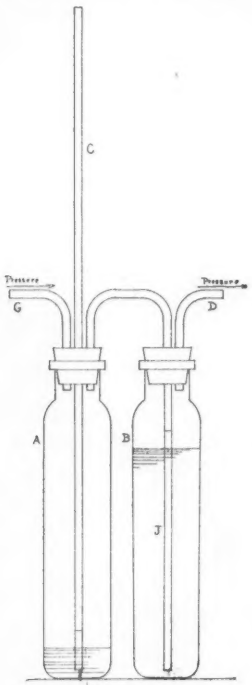


FIGURE 1

Figure 1 illustrates, in simple form, the method of balancing one column of liquid against another, as a measure of their respective densities. A small amount of distilled water was introduced into A, and a considerably larger amount into B. The capillary rises, in centimeters, in tubes C and J were recorded. As pressure was applied at G the liquid rose in C until bubbles of air were forced from the mouth of J. At that moment the height of the column of water in C minus the sum of the capillary rises in C and J was exactly equal to the submerged part of J.

Another liquid, X, heavier than water, was introduced into B, and the process repeated. The height to which the water rose in C was greater by direct proportion as follows:

$$\frac{\text{Rise Water}}{\text{Density Water}} :: \frac{\text{Rise } X}{\text{Density } X}$$

From this simple device an apparatus as illustrated in Figure 2 was developed, which is quite as accurate as the Westphal balance or the pycnometer.

Since too great a quantity of liquid, whose density was to be determined, was required, and since greater range of rise tended more nearly toward exactness it was decided that tubing of smaller bore and greater length should be used. Tube B measures about $1^3/_4$ by 45 cm., while the smaller glass tubing is of 2 mm. bore. As with the Westphal balance, 100 cc. of liquid will suffice.

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta meeting, April 7–11, 1930.

The necessary pressure was obtained by filling the separatory funnel, *I*, with tap water, and allowing it to drip into *G*. When *G* has been filled to a reasonable height the water may be drained by opening *H*, the pressure in *G* being sufficient to start the siphon. *L* is then opened in order that the siphoning may continue.

B is connected by means of a rubber tube to a drawn-out test tube, *E*, with which the column in *B* may be balanced.

J is etched at a point near the top of *B*, in order that, after balancing, the height of all columns of liquid introduced into *B* may be the same.

A, *B*, and *E* are immersed in water in a two-liter graduate, *F*, which acts as a thermostat.

Thermometers register both the thermostat and stem temperatures. It was found that the water in the stem expanded approximately 0.0026 millimeter per centimeter of liquid in the stem for every degree of temperature above that of the liquid in the thermostat, beginning at 20.0°C.

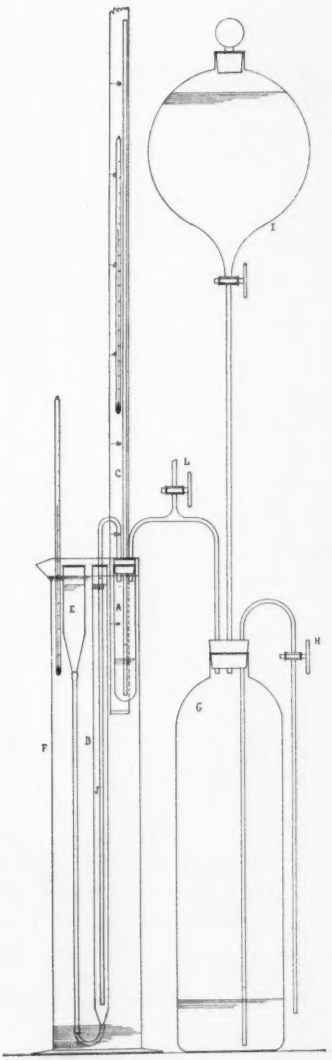


FIGURE 2

Experimental Part

The measured distance between the mouth of *J* and the etch was 40.45 cm.

Distilled water was introduced into *A* and *B*. *L* was then opened, allowing capillarity to exert itself unimpeded. The capillary rises in *C* and *J* were, respectively, 1.2 and 0.90 cm.[1]

L was then closed, and pressure applied. As bubbles of air began to escape at the mouth of *J*, at the rate of about 60 per minute, the column of

[1] On account of the fact that it was impossible to obtain two tubes here of the same and uniform bores, capillary rises in *C* and *J* were not equal.

water in B was balanced so that its meniscus was even with the etch on J. The column of water in C was then 42.55 cm. in height,

$$42.55-(1.2+0.90)=40.45 \text{ cm.}$$

which discloses the fact that the height to which the column of water had been forced in C was exactly equal to the submerged part of J.

L was opened, and the water in B was transferred to the Westphal balance whose cylinder was submerged in water of the same temperature as that of the thermostat. Its gravity was 0.9998. The temperatures of thermostat and stem were respectively 18.0 and 18.2 degrees C. The correction for stem temperature was, therefore, neglected.

The process was repeated with an impure sample of methyl alcohol. The temperature had not altered appreciably. Capillary rises in C and J were 1.2 and 0.30 cm., respectively, while the major rise in C was 34.20 cm.

$$34.20-(1.2+0.30)=32.70 \text{ cm.}$$

The following proportion was written:

$$40.45 : 0.9998 :: 32.70 : X$$
$$X = 0.8083$$

The Westphal balance verified the gravity as 0.8083.

With a potassium chlorate solution, heavier than water, the following results were obtained:

$$40.45 : 0.9998 :: 43.00-(1.2+0.78) : X$$

$X = 1.0141$, as also was given by the Westphal balance.

Liquid	*Rise*	*Tested gravity*	*Wphal. bal. gravity*
Water	40.45	....	0.9998
CH_3OH	32.70	0.8083	0.8083
$KClO_3$	41.02	1.0141	1.0141

Through a great number of determinations, ranging over a period of two months, results have all been most satisfactory. May I suggest at this point that the speed with which determinations may be made might be increased if tube C and the meter stick were replaced with a graduated tube; and tube J graduated in millimeters for a short distance on each side of its etch.

By means of this apparatus the student of chemistry or physics may see the difference in volumes of liquids of the same weight; may, so to speak, actually see the difference in their densities.

Also, because of the inexpensiveness of the apparatus, which may be easily set up with materials found in every laboratory, it may, due to its accuracy, cope with the Westphal balance or the pycnometer.

DUPLEX WEIGHING TUBE*

W. E. Eskew and Frank C. Vilbrandt, University of North Carolina, Chapel Hill, N. C.

A new sample weighing and delivery device is presented.[1] Loss of sample with subsequent inaccuracy of analytical data is likely to occur when samples must be transfered from a watch glass or weighing bottle into a beaker or narrow neck receptacle. Flicking of sample may also occur when the material must be brushed out of the weighing bottle or off the watch glass with a camel's hair brush. When standard solutions are being prepared, the narrow neck of the volumetric flask presents a problem in transference, which is usually solved by inserting a funnel into the flask, dusting the chemical out of the weighing bottle or watch glass into the funnel and washing the chemical into the flask. Oftentimes the sample is dusted from the weighing receptacle onto glazed paper, then the paper slightly grooved and the sample bushed into the beaker, test tube, or flask from the paper.

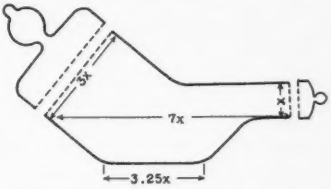


Figure 1.—Side View of Duplex Weighing Tube

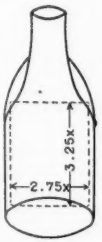


Figure 2.—Top View

In order to eliminate the danger of loss due to dusting and flicking of the brush and to obviate the necessity of double transference, a weighing tube or bottle has been designed to incorporate the principle of a watch glass or weighing bottle, provided with an accessible and easily discharging delivery end. The device consists of a wide-mouthed glass tube with a flattened bottom side and a tapering delivery end turning up and away from the flattened side. The duplex weighing tube or bottle is shown in Figure 1. Details of size are given, but proportionally larger or smaller sizes are just as applicable. Figures 2 and 3 give top and end view of the duplex tube. The use of outside ground joints and caps on both ends enables the application of this weighing tube or bottle for all purposes of weighing.

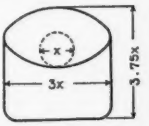


Figure 3.—End View

The advantages in the specific details of the design given are as follows:

(1) The large mouth provides for easy addition of or taking portions of the sample from the tube.

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta meeting, April 7–11, 1930.

[1] The conception of the duplex tube came from the use of an adapter by W. E. Eskew in weighing small samples of dye to transfer to a test tube.

(2) The designed slopes permit easy access of brush or stream of water into and against all parts of the interior.

(3) The flattened side permits proper upright position during weighing and standing.

(4) Distribution of the mass of glass assists in preventing the tube from easily toppling over.

(5) Narrow end or stricture at delivery end permits easy transfer of solids or liquids into narrow neck receptacle.

(6) Variation of size for weighing larger or smaller samples does not involve proportional bulkiness.

New Products from Diphenyl. Diphenyl, being commercially produced by the Federal Phosphorus Company, has now been made available in quantity and at moderate prices. It forms the starting point for a number of new products which are being developed by the company.

Chief among them is a series known as the "Aroclors," substances which have been derived from diphenyl by chlorination. The "Aroclors" range from colorless liquids of low viscosity to hard brittle resins. Their properties suggest that they may prove suitable for many purposes such as solvents, high-boiling lacquer diluents, gums in nitrocellulose lacquers, varnish gums, waterproofing agents, plasticizers, softeners for photographic films, and dielectric oils.

Although the "Aroclors" are perhaps the most important group of substances which the Federal Phosphorus Company has thus far developed from diphenyl, they are not the only ones. Wetting agents for textile fabrics, foaming and emulsifying agents, and a high-boiling hydrocarbon mixture are also being made.

These developments constitute another example of the results of research, first in perfecting an industrial process for material which has not previously been available in sufficient quantity or at a low enough price to permit of its use for any purpose at all, and then in developing from this basic material other new products which have a wide range of possibilities.—*Ind. Bull.* of *Arthur D. Little, Inc.*

The Work for Agriculture of Two Great Englishmen. One of the most prosperous periods of British agriculture was between the years 1840 and 1870. During these years the production of the soil was increased between 40 and 50 per cent. At the beginning of the period the average wheat yield was hardly twenty bushels per acre, and at the end it was approaching thirty bushels. There were many reasons for this increase, but one of the greatest was the research work done with artificial fertilizers by Lawes and Gilbert. The work which these two Englishmen did for agriculture, and what has been the outcome of such work, is most admirably set out by Sir John Russell in his lecture, now published in pamphlet form, to the Cawthron Institute, New Zealand. Sir John is the present Director of Rothamsted Experimental Station, the oldest agricultural research station in the world, being founded by Lawes in 1843.—*Science Progr.*

ELECTRICALLY HEATED SAND-BATH HOT PLATES FOR ANALYTICAL LABORATORIES*

G. Frederick Smith, The University of Illinois, Urbana, Illinois

The problem of providing for extensive analytical evaporations, particularly in the case of large-scale operations in which hundreds of evaporations are conducted simultaneously, offers difficulties. Such operations as the quantitative concentration of beaker filtrates, the digestion of precipitates and particularly evaporations to dryness with subsequent digestion for dehydration processes call for special designs of hot-plate construction.

The object of the present work is to provide data to cover the construction of various sizes of laboratory hot plates which will cover the various working conditions outlined and be made from standard stock electrical heating units and otherwise easily cut, machined, and assembled supporting parts. Provision is made for easy replacement of "burned out" heating units which, under the principles of assembly, becomes infrequent if at all necessary. As far as is known there is not obtainable from the usual laboratory supply houses such equipment or a satisfactory substitute. The designs about to be described have been in use in the laboratories of the University of Illinois for an extended period of time and have proved entirely satisfactory and the first heating unit has yet to be replaced.

Heating Elements Selected

Standardized electrical space heaters are obtainable from various sources, advertised and advocated for a wide range of heating problems such as vacuum driers, annealing ovens, air-drying operations, and oil- and paraffin-bath heaters, etc., for which high-pressure steam is either not suited or of not sufficient heat capacity and temperatures up to and somewhat under the first visible red heat are desired. Such space heaters are designed to function indefinitely if not too severely insulated. The type selected for the problem at hand was the G. E. X. 1183 space heater, 500 watts capacity, working under a potential of 110 volts. The heaters are provided with contacts at each end insulated from the remaining metal parts of the heater so that they may be mounted on a conducting support without further insulation. They are not expensive and replacements are always accessible but seldom required.

Mounting the Space Heater

The material employed in the construction of such an electrical hot plate consists of the following list in addition to 4 space heaters just described:

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta meeting, April 7–11, 1930.

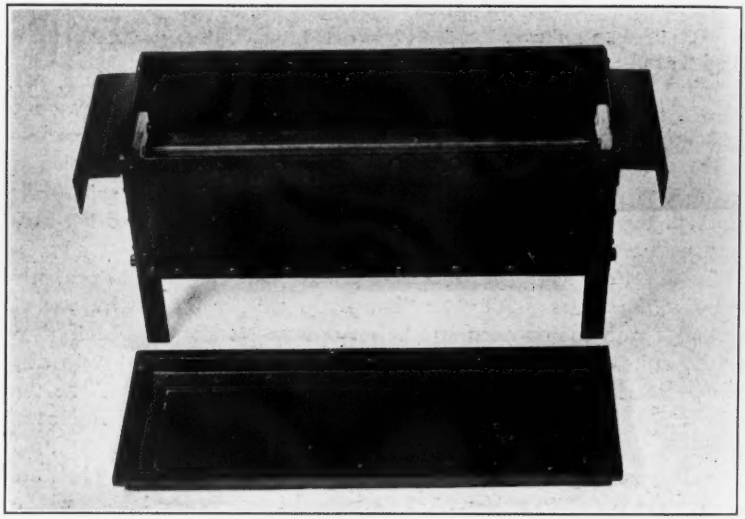


FIGURE 1

22-gage galvanized sheet iron (2 pcs., $20^1/_4 \times 26^1/_4$″)
(2 pcs., $7 \times 26^1/_4$″)
(2 pcs., $7 \times 20^1/_2$″)
1-inch angle iron (4 pcs., $26^1/_4$″)
(4 pcs., $20^1/_2$″)
(4 pcs., 12″)
1-inch $\times$ $^1/_8$-inch strap iron (4 pcs., $24^1/_4$″)
(4 pcs., 20″)
$^3/_8$-inch square iron (2 pcs., 24″)
(2 pcs., 21″)
"Flat" and "bent" corner braces $2^1/_2$-inch and 2-inch, respectively (4 pieces each).
$^5/_{16}$-inch $\times$ $^1/_2$-inch cap screws (8 pieces)
"4 lb." tinned rivets (100 pieces)
$^3/_8$-inch round head machine screws 10–24 thread (24)
Round head stove bolts $1 \times {}^3/_{16}$″ (24)
Transite board $^3/_8$ x $2^1/_2 \times 20$″ (1 piece)
Black enamel or asphaltum paint (1 pint)

The amounts listed in parenthesis following each item represent the amount and size used in each of the hot plates employing four heating units and illustrated in Figure 2.

Three different hot plates are pictured in the partially assembled condition in Figures 1, 2, and 3. The body of the arrangement (selecting Figure 2 again for illustration) is a shell seven inches deep with an area at the top $20^1/_2 \times 26^1/_2$ inches with the space heaters extending across the $20^1/_2$-inch dimension. The heaters are mounted with their flat side

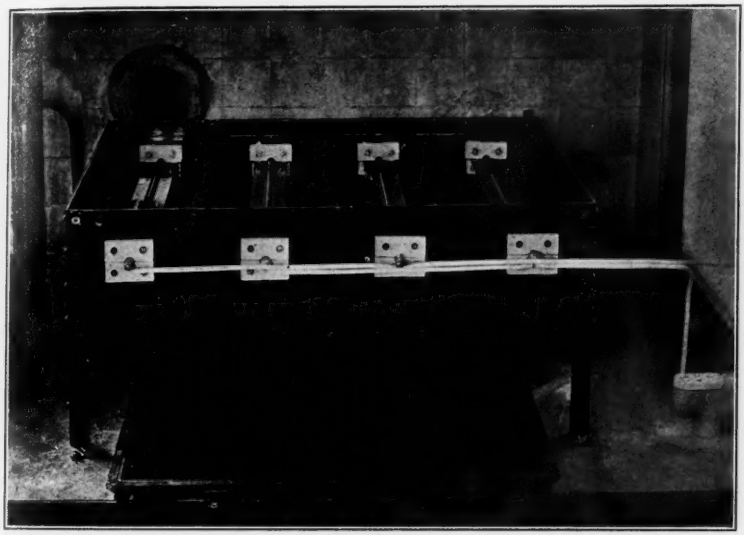


FIGURE 2

in a plane with the top and bottom of the bath and are placed two inches from the top edge of the hot plate.

The four legs are of one-inch angle iron framed at the top with one-inch strap iron, and at the bottom with one-inch angle iron so placed that the bottom of the bath is one inch elevated from the outside bottom edge of the shell. The angle iron frame supporting the bottom of the bath is fastened to the legs by the use of cap screws. The strap iron frame for the support of the top tray is fastened to the upper part of the four legs using machine screws. The galvanized sheet iron sides and bottom are riveted into place on their frame work support and a clearance of 6 inches underneath is provided by the length of the legs.

The top tray is framed in a similar fashion using angle irons, sheet iron, and square iron. It is one inch deep and the square iron outside border acts as its support when in position in a fashion clearly shown in Figure 1. The top tray is held into position against any tendency to warp, using a small screw and clamp shown in Figure 2 lying at the bottom of each leg.

The space heaters are inserted through a slot made in the front and back of the side walls $2 \times {}^1/_2$ inches in size and are supported against contact with the remaining metal of the bath by two pairs of transite stirrups fastened within and without the bath by machine bolts. A further description of these need not be made since the illustrations are sufficiently

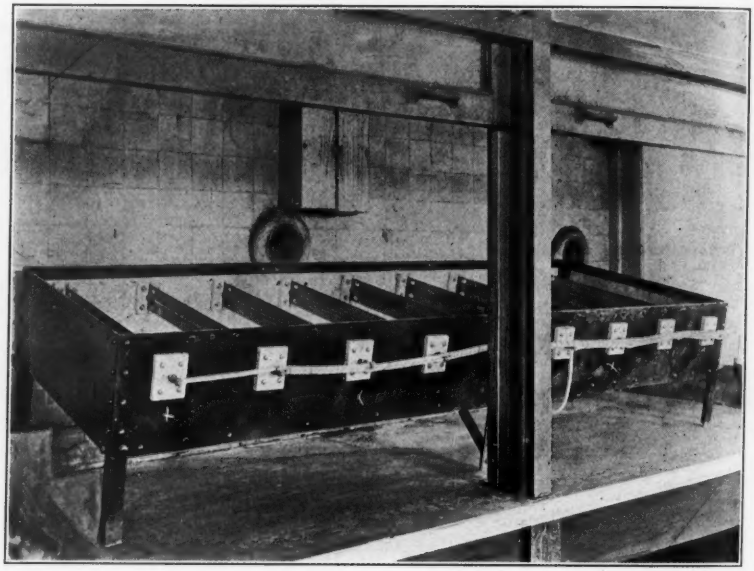


FIGURE 3

clear on this point. The space heaters may be reversed in position in the bath from that given as illustrated in Figure 3 and stand with their flat side vertical to the plane of the top and bottom of the bath. With the top tray in position the space heaters are in the first case one inch below the bottom of the tray and in the latter case almost in contact with the bottom.

To prevent most of the downward radiation from the space heaters from being dissipated on the bottom side of the hot plate the space within the heating chamber is filled with infusorial earth or a substitute to within $^1/_2$ inch of the space heater if mounted with the flat side in the plane of the bottom and up to the space heater if mounted in the opposite position.

In Figure 1 a hot plate with one space heater and therefore consuming 500 watts of electrical power is shown. In Figure 2 the four-unit type is shown. In this case the space heaters are connected in series by pairs of two and each of the two pairs thus formed wired in parallel with the main 110-volt lead wires. In Figure 3 is pictured the nine-unit type. In this case the four coils of each end are wired exactly as in Figure 2 and the middle space heater is provided with a switch (not shown because on the bottom side) by which it can be heated or turned off as desired. In

all cases the wires leading to the main conduit and switch box are asbestos insulated and in all the hot plates a guard to protect the bare wires and contacts is mounted on the side of the bath as shown in the case of Figure 1. When the top trays are in position sand $^3/_8$ to $^1/_2$ inch thick over the whole tray is provided.

Upon calculation the power consumed with the four-unit hot plate of Figure 2, like Figure 1, is approximately 500 watts. Since the hot plate of Figure 3 is an assembly of the hot plate of Figure 1 as the middle portion and both ends the duplicate of that of Figure 2, with the switch of the middle coil in contact there is a consumption of 1500 watts or with the switch of the middle coil off the power consumption is 1000 watts.

The Hot Plate Performance under Varying Conditions

The performance of such a hot plate will cause the temperatures attainable to fluctuate with the room temperature, draft in the hood in which it is installed, and fluctuations in line voltage. Otherwise, the evaporation vessels will vary in temperature depending upon their position on the various plates and the depth to which they are immersed in the sand of the top tray.

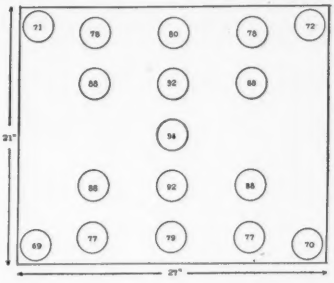


FIGURE 4

Temperatures attainable in various positions of the hot plate of Figure 1 were determined by placing at various positions 125-cc. Erlenmeyer flasks containing 50 cc. of concentrated sulfuric acid provided with a suitable thermometer. The flasks were submerged through the $^3/_8$ inch of the sand of the tray and when temperature equilibrium was attained the results recorded. The diagram of the results obtained is shown in Figure 4. The temperatures are in centigrade degrees for a room temperature of 20 degrees. It will be observed that the temperature graded downward from the center position diagonally and radially in all directions. This hot plate proves admirable for quantitative evaporations just under the normal boiling point of water. Under the conditions as given the bottom of the bath will permit of contact with the back of one's hand without discomfort. Under the hot plate is an admirable storage space for beakers and contents undergoing yet

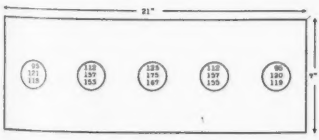


FIGURE 5

milder evaporation or digestion or for beakers completely evaporated and awaiting an opportune time for the operator's attention.

The operation of the single unit hot plate of Figure 1 under the conditions stated is shown in Figure 5. The top row of figures are for the Erlenmeyer flasks resting on top of a $^3/_8$-inch thickness of sand, the middle row for the same flasks buried $^1/_2$ inch in sand and the bottom row the same flask buried $^3/_8$ inch in sand. This bath is admirable for evaporations to fumes of sulfuric acid, the dehydration of metasilicic acid for silica determination and similar operations. The legs of this hot plate elevate the bath proper 5 inches above the supporting bench instead of six inches as in the case of the other hot plates. This change is made to bring the leg length into better proportion with the remainder of the dimensions.

The operation of the eight-unit hot plate is shown in Figure 6 with the test flasks buried $^3/_8$ in the sand. The upper portion of Figure 6 records temperatures for one-half of the hot plate with the middle coil operating. The lower part of Figure 6 shows the same with the middle coil cut out of the electrical circuit. The nine-unit hot plate is seen to be the duplicate in heating range of two four-unit plates, two single-unit plates, and a still higher heating portion in the middle area over the 500-watt space heater while the full power is on. With the middle 500-watt space heater cut out the nine-unit hot plate is practically the equal in heating range and area to three of the four-unit types.

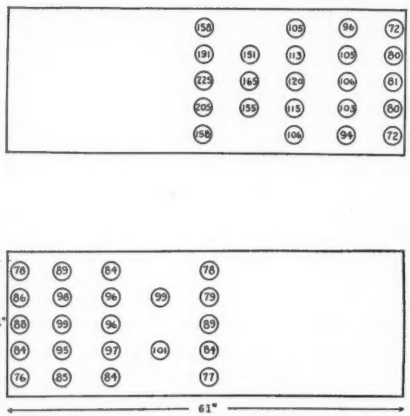


FIGURE 6

Further Variations in the Operations of the Hot Plates Described

Many other desirable combinations of wiring can be made besides those mentioned. By varying the thickness of the sand layer in the top tray or by its complete omission further temperature graduations may be obtained. By providing an air insulation at the bottom of the bath by closing up the one-inch recession of the bottom above the outside bottom edge, a further increase in radiation upward could easily be provided.

The construction of these hot plates is greatly facilitated by the operation of making a number at one time through the use of templets, multiple drilling and fitting, tandem sawing, etc. It is hoped that this description

is sufficiently clear that prospective users of this equipment can have the same prepared in their own machine shops. The author in any event will be glad to supply additional information if desired and other ways assist in making this apparatus available at the request of those interested.

Carnegie Scientists Report Three Kinds of Water in Ocean. There are three different kinds of water in the ocean, scientists of the Carnegie Institution of Washington, one of whom belonged to the staff of the ill-fated, non-magnetic ship, "Carnegie," reported recently to the American Geophysical Union.

Results of some of the deep sea determinations of the "Carnegie," which was destroyed with the loss of Captain Ault and the cabin boy in Western Samoa last November, were commented on by H. W. Graham, biologist and chemist, in a paper presented by Dr. J. A. Fleming, as follows:

"These samples show that the waters may be divided into three general layers: An upper layer where an active plant and animal life is maintained, a middle layer in which a decomposition of organic remains is taking place, and a lower layer which represents water which has been conducted from polar regions. The upper layer shows high values of dissolved oxygen but low values of phosphates, silicates, and hydrogen-ion concentration. The middle layer is low in oxygen but is high in phosphates and silicates and is relatively less alkaline. The lower layer tends toward conditions at the surface with again higher values of dissolved oxygen and lower values of phosphates, silicates, and hydrogen-ion concentration."

How a shotgun and stop-watch were used to determine the distance to the bottom of the ocean when the sonic depth-finding apparatus broke was told by Floyd M. Soule, of the ship's staff of scientists, and C. C. Ennis. The depth-finding apparatus, which was borrowed from the U. S. Navy, is an electrical device for accurately measuring the time it takes a sound to travel to the bottom of the ocean and return. Knowing the speed of sound in water, the scientists could then quickly calculate the depth of the ocean.

"A steel breech just long enough to hold a 16-gage shotgun shell was screwed into one end of a length of brass pipe," the paper said. "The pipe acted as a holder and also as a guide for a heavy steel firing pin which was dropped into the upper and open end of the pipe, the shell end being held a foot or two below the surface. The hydrophones were used to pick up the echo and a stop-watch used to measure the elapsed time. Soundings were taken in this manner twice a day. These were only roughly approximate because of the inaccuracy of the stop-watch measurement and because of the uncertainty of the velocity of a sound set up by an explosion. However, it was a case of half a loaf being better than none, and the device materially assisted in the routine occupation of oceanographic stations."

Sound sent to the ocean's floor behaved strangely and in ways unaccountable by the scientists. Sometimes the reflection would be loud from depths and weak from shallows. Again loud echoes and faint echoes would come from places where all known conditions were similar and even where bottom samples were very much alike. The echoes from five-mile soundings were stronger than those often heard from less than one mile.

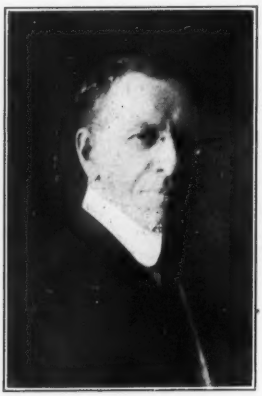
In water sound travels nearly a mile every second, more than four times as fast as it does in air. On several occasions signals were picked up after traveling 25 miles back and forth between the bottom of the ocean and the surface, and once they had gone nearly 50 miles, having been reflected 15 times when last heard.—*Science Service*

EDUCATIONAL INSTITUTIONS IN CINCINNATI AND VICINITY

E. J. Morgan, St. Xavier College, Cincinnati, Ohio

University of Cincinnati

Cincinnati, which is famed as an educational center, boasts of one of the largest and most progressive municipal universities in the country, and the second largest university in Ohio. The University of Cincinnati, with a present enrolment of about 12,000 students, had its origin in the College of Liberal Arts, founded in 1870. Eight other colleges and schools were added later. One of the features of the institution is the co-operative plan on which the College of Engineering and Commerce is run. This system, instituted by Dr. Herman Schneider, now president of the university, consists of alternating periods of two weeks or a month at practical work in the industries and in the classroom, a program which has been adopted by several other institutions in the country. Through its evening classes in the Colleges of Liberal Arts, Education, Engineering and Commerce, and School of Applied Arts, the University serves nearly 5000 persons, most of whom would otherwise be unable to take advantage of its educational facilities.



Dr. Herman Schneider, President, University of Cincinnati

Chemistry is taught by two distinct departments, the Department of Chemistry of the Liberal Arts College and the Chemical Engineering Department. The two departments occupy the same building, which is well equipped for courses in metallurgy, chemical engineering, industrial chemistry, and liberal arts chemistry. Bonds were approved, at a recent municipal election, for an addition to the chemistry building.

St. Xavier College

Another institution which has contributed greatly to the intellectual development of Cincinnati is St. Xavier College, conducted by the Fathers of the Society of Jesus. It is now located in Avondale, a restricted residential suburb of the city, having been moved from the heart of the city in 1919. Subsequent years have witnessed a rapid development in academic and physical growth so that there are now seven buildings, including a chemistry hall equipped to take care of a full four-year undergraduate course in chemistry.

Ind. Eng. Chem., News Ed.

AIRPLANE VIEW OF 50-ACRE UNIVERSITY OF CINCINNATI CAMPUS, COLLEGE OF MEDICINE GROUP IN BACKGROUND

CHEMISTRY BUILDING, UNIVERSITY OF CINCINNATI

HINKLE HALL, LIBRARY, AND CHEMISTRY BUILDING, ST. XAVIER COLLEGE, CINCINNATI, OHIO
Ind. Eng. Chem., News Ed.

At present 250 out of a total of 1000 students are enrolled in the chemistry courses. To fittingly commemorate the centennial celebration of the founding of the college being planned for 1931, the chemistry department will institute graduate courses and confer scholarships on those undergraduates who manifest special aptitude in the science.

Women's Colleges

The city also boasts of two Catholic women's colleges: the Clifton College of the Sacred Heart, conducted by the Madames of the Sacred Heart, and Mount St. Joseph College in Delhi, conducted by the Sisters of Charity. Both of these institutions have well-equipped chemistry departments.

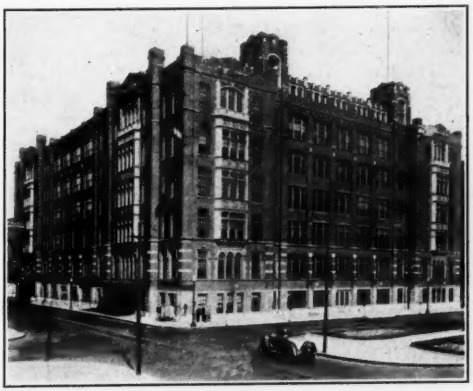
At Oxford, Ohio, is the Western College for Women, founded seventy-five years ago, and having a present enrolment of 400, 70 of whom are taking chemistry courses.

Ohio Mechanics Institute

The Ohio Mechanics Institute, founded in 1828 for the purpose of educating industrial workers, holds a unique position between the university and high school in the educational life of Cincinnati. Its curricula include day and evening classes covering a four-year technical high-school course and many special trade courses.

Miami University

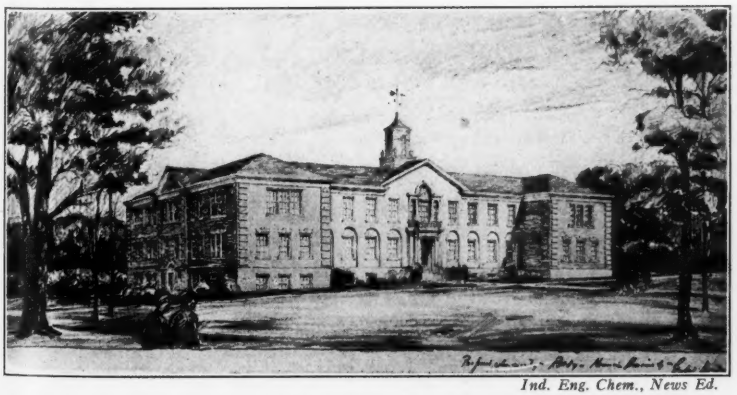
Miami University, now in its 121st year, at Oxford, Ohio, 40 miles from Cincinnati, is one of the three universities maintained and directed by the State of Ohio. It has a new chemistry building devoted wholly to chemistry.



OHIO MECHANICS INSTITUTE

University of Dayton

The University of Dayton, located in Dayton, Ohio, is in charge of the Fathers and Brothers of Mary. A new chemistry building is about to be erected and when completed will house the chemistry and the chemical engineering departments.



Ind. Eng. Chem., News Ed.

NEW CHEMISTRY BUILDING, MIAMI UNIVERSITY, OXFORD, OHIO, NOW UNDER CONSTRUCTION

Removal of Stains. How the removal of stains has become a branch of the work of the chemist was explained in a lecture at Leicester Technical College, England, by Mr. H. L. Long, head of the chemistry section, who also gave several demonstrations of removing stains of the chemical, oily, and mildew types. A book on the subject, he stated, had been published as early as 1583, when the majority of the garments worn were colored.—*Chem. Age*

PRELIMINARY ANNOUNCEMENT—CINCINNATI MEETING, SEPTEMBER 8–12, 1930

The eightieth meeting of the American Chemical Society will be held in Cincinnati, Ohio, during the week of September 8th.

Program: The Division of Chemical Education is planning an attractive program which will include a symposium on "The Qualifications of Chemistry Teachers" and several sessions, for the discussion of miscellaneous papers. It is probable that these program sessions will be confined to Tuesday, Wednesday, and Thursday.

Business Meetings: The Senate will meet Wednesday to receive committee reports while the Division will hold a brief business meeting Thursday, the chief item of business being the election of officers.

High-School Teachers: The Division is anxious to establish contacts with every teacher of chemistry. On Wednesday, September 10th, through the courtesy of Mr. Wm. W. Buffum, the Division and Senate will be hosts at luncheon to all high-school teachers in the Cincinnati area. These guests will also attend the symposium.

Special Student Rates: The Society has voted to allow any regularly matriculated student, majoring in chemistry in any college or university, to register for the entire meeting for $3.00, instead of the $8.00 which is charged non-member chemists. Sleeping accommodations at a nominal rate may also be secured by addressing the Local Secretary, Father E. J. Morgan, St. Xavier College, Cincinnati, provided arrangements are made in advance of August 16th.

Exhibits: Manufacturers of chemical apparatus and products, high-school and college laboratories, and other agencies which are interested in chemical education are invited to send exhibits for the Cincinnati Meeting. Free exhibition space will be reserved upon request to the Local Secretary, but each exhibitor must assume all costs of transportation and packing as well as responsibility for breakage and loss.

A prize of $10.00 is offered by the Division for the best exhibit prepared by a high-school chemistry class.

Papers for the Program: Notice to Authors

By vote of the Council of the A. C. S., papers by American chemists not members of the A. C. S. shall not appear on the program unless they be joint papers with Society members, and no papers may be presented at a meeting unless the title has been printed on the final program.

Titles for papers designed to be read before the Division of Chemical Education should be sent as early as possible to the Secretary of the Division. The rapidly increasing number of papers makes the exclusion of some inevitable. Papers for the symposium on The Qualifications of Chemistry Teachers will be by invitation.

It may be of interest to experienced teachers that requests have been received by the Secretary for papers on the topics shown in the following list.[1]

1. Duplication in High-School and College Courses.
2. A More Intensive Study of a Limited Field in High-School Chemistry.
3. How Best to Use the Conceptions of Sub-Atomic Structure in Teaching High-School Chemistry.
4. What Products and Processes of Chemical Industry Should Be Included in Introductory Chemistry?
5. Recording Laboratory Notes.
6. Retaining Good Teachers of Chemistry in Competition with Industry.
7. In Training Chemists Should Regular Courses in the Mathematics Department Be Supplemented by Special Courses Offered by the Departments of Chemistry and Physics?
8. The Neglect of Cultural Subjects in Scientific Courses of Study.

[1] As a by-product of a recent letter-ballot, the topics listed have been suggested by members of the Senate of Chemical Education as suitable for early discussion. A much longer list may be had by addressing the *Secretary*.

9. Teaching Theory and Chemistry Calculations in High School.
10. How Much Modern Language Should Be Required for College Chemistry?
11. A Year of General Chemistry in College vs. the One-Semester Plan.
12. The Place of History in First-Year College Chemistry.
13. The Place of Research in Undergraduate Chemistry Courses.
14. Desirability and Use of the So-Called Comprehensive Examination in College Courses Leading to the Bachelor's Degree.
15. Distinctly Different Courses for High-School and College Chemistry.
16. Is There an Implied Responsibility on the Part of the Director of the Chemistry Course to Get the Young Graduate His First Job?

It is important to note that one copy of the *completed* paper together with two copies of an abstract must reach the Secretary not later than August 1st. Manuscripts received after this date will be held over, with the author's consent, for the Indianapolis Meeting in April, 1931.

Papers read before the Division become the property of the Society, and, if acceptable for publication, will appear later in the JOURNAL OF CHEMICAL EDUCATION.

Since the time available for each paper will be strictly limited, authors are earnestly requested to coöperate as follows:

1. Condense the material so that it may be presented in 5–8 minutes, leaving time for adequate critical discussion which should be one of the chief functions of our program meetings. In general, only fifteen minutes, including discussion, will be allotted any one paper.
2. Organize significant features on slides, films, or in mimeographed form for distribution.
3. Do not send in a title unless you expect to be present to read your paper.

R. A. BAKER, *Secretary*,
Syracuse University, Syracuse, New York

Complicated Changes in Elements Surpass Dreams of Alchemists. Changing one chemical element into another by the action of a third element and in the process obtaining two still different elements is the atomic juggling described recently to the American Chemical Society by Dr. William D. Harkins, of the University of Chicago, and Dr. Arthur E. Schuh, of the Bell Telephone Laboratories. The experimenters were not able to obtain changed elements in any useful quantities, but have been working with single atoms, observed by the indirect process of watching the cloud of fog they leave behind them as they dash through a chamber containing water vapor at low pressure.

Nitrogen, the element that makes up some three-quarters of the air we breathe, was what they started out with. It was bombarded with alpha particles—nuclei of helium atoms given off by thorium, an element like radium, while disintegrating into another element. There is no way of aiming the atomic bullets, but after a long enough series of trials an occasional hit may be scored. Dr. Harkins and his associate studied nearly half a million tracks of atoms, and only found two that showed evidence of a disintegration of the atoms into another element.

Here is the complicated series of events they believe to take place in the instant of time that the change requires: the alpha particle, or helium nucleus, attaches itself to the nucleus of the nitrogen atom. It thus becomes the nucleus of an atom of fluorine. In less than a millionth of a second, however, the fluorine nucleus emits a fast hydrogen particle, or proton, part of the atomic nucleus. The remaining part is the nucleus of an oxygen atom of mass 17. Ordinary oxygen has an atomic weight of 16, but it has a variant, or "isotope," of atomic weight 17.—*Science Service*

SALARIES, EXPERIENCE, AND TRAINING OF CHEMISTRY TEACHERS IN OHIO HIGH SCHOOLS*

EARL W. PHELAN, GEORGIA STATE WOMAN'S COLLEGE, VALDOSTA, GEORGIA

Method and Purpose of the Investigation

The present paper is an attempt to show what data are available in answer to the following questions.

(1) In what schools are our teachers being prepared?
(2) What training do they have?
(3) What initial salaries do they receive?
(4) What are the prospects for the future of a new teacher?

The data used were secured from the principals' reports filed in the office of the state director of education. No attempt was made to obtain complete figures from the county schools whose reports were incomplete, but personal letters were sent to the eighteen principals of city or village high schools for which complete information was lacking. All but three replied. The following tables therefore represent summarized information concerning 290 out of 302 teachers in county high schools and 188 teachers in city and village high schools.

Preparation of the Teachers

In Table I is shown the distribution of the highest degrees held by the teachers.

TABLE I

	County	*City*	*Total*
None	7	0	7
A.B.	133	67	200
B.S.	132	70	202
M.A. or M.S.	26	45	71
Ph.D.	0	5	5

Eighty-four of the county teachers had taken summer school work after receiving the degrees listed above.

Table II shows the subjects studied as major subjects in college.

TABLE II

	County	*City*	*Total*
Science	75	30	105
Chemistry	45	102	147
Mathematics	38	12	50
Biology	21	7	28
History	21	1	22
Education	18	5	23
English	17	5	22
Agriculture	10	0	10
Physics	7	11	18
Scattering	43	11	54

The above data show that in the smaller schools the teachers must be hired to teach a variety of subjects, only one of which can be the specialty, while in the larger schools teachers are usually hired to teach the subject of major interest. This tabulation necessarily includes all who taught chemistry during the year 1928–29, although most of them were teach-

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta meeting, April 7–11, 1930.

ing from one to seven other subjects in addition (*2*). For many, chemistry was of but incidental interest. It is unfortunate, but not at present capable of remedy, that but thirty per cent of all the Ohio chemistry teachers majored in chemistry in college.

Table III shows the schools from which the county teachers were graduated. Reports on the city teachers failed to include this information.

TABLE III

Source of Collegiate Preparation

Ohio Colleges	*Undergraduate*	*Graduate*
Ohio State Univ.	31	61
Ohio Northern Univ.	24	0
Miami	21	2
Ohio University	21	0
Wilmington	18	3
Otterbein	13	0
Muskingum	12	3
Wooster	11	1
Defiance	11	0
Ohio Wesleyan	9	0
Wittenberg	9	2
Bowling Green	8	2
Heidelberg	8	0
Bluffton	7	0
Kent	7	7
Mount Union	7	0
Ashland	6	0
Hiram	5	0
Kenyon	5	0
Antioch	3	0
Capitol	3	0
Denison	3	0
Rio Grande	3	0
Oberlin	2	0
Western College	2	0
Akron	1	4
Cincinnati	1	3
Toledo	1	1
Baldwin-Wallace, Findlay, Lima, Marietta, one each		

Out of State Colleges		
Manchester, Indiana	6	
Franklin, Indiana	3	
Michigan	3	1
Indiana	2	1
Adrian	2	
Chicago	0	12
Columbia	0	4
Southern California	0	2
West Virginia	0	2
Wisconsin	0	2

Out of State Colleges

Asbury, Ball Teachers' College, Berea, Bethany, Cornell, Fletcher, Goshen, Huntington, Illinois College, Kirksville, Missouri, Lake Forest, Lebanon, Marion, Olivet, Purdue, Rochester, Stetson, Syracuse, Thiel, Illinois, Westminster, one each undergraduate, and Milton, Illinois, and Colorado, one each graduate.

Summarized, the undergraduate work was done in schools of the following types.

	Ohio	*Out of State*
State univ.	31	6
State teachers' coll.	15	8
Large endowed univ.	0	3
Small denom. college	210	20

Most of the graduate and summer school work was done in the state university. Generally speaking, the smaller denominational colleges of the state seemed to supply the demand in the territory immediately surrounding them.

Factors Governing Teaching Salaries

The effects of many of the factors which control the salary paid a teacher obviously cannot be gaged in a study of this kind. But two render themselves capable of any extended study: (1) teaching experience

TABLE IV

Experience and Salaries

COUNTY HIGH SCHOOLS

1 year		*2 years*		*3 years*	
Salary	*Number*	*Salary*	*Number*	*Salary*	*Number*
$1100	1	$1300	2	$1200	2
1200	6	1400	6	1300	1
1300	10	1500	6	1400	11
1400	9	1600	4	1500	3
1500	5	1700	2	1600	5
1700	1	2000	1	1700	3
2100	1	2100	1	1800	3
				1900	2
				2000	1

4 years		*5 years*		*6 years*		*7 years*	
Salary	*Number*	*Salary*	*Number*	*Salary*	*Number*	*Salary*	*Number*
$1200	1	$1300	1	$1400	3	$1400	2
1400	1	1400	4	1500	6	1500	2
1500	4	1500	2	1600	3	1600	2
1600	5	1600	2	1800	3	1700	2
1700	2	1700	2	1900	4	1800	1
1800	3	1800	4	2000	4	1900	1
1900	3	2000	4	2100	1	2000	1
2000	4	2200	1	2200	2	2100	1
2100	1	2300	1	2800	1	2200	3
2300	1	2400	2			2300	3
						2500	1
						2600	1
						2700	1

8 years		*9 years*		*10 years*		*11–15 years*	
Salary	*Number*	*Salary*	*Number*	*Salary*	*Number*	*Salary*	*Number*
$1200	1	$1400	1	$1400	2	$1400	1
1300	1	1500	1	1500	1	1600	1
1400	1	1700	3	1600	1	1700	1
1600	2	1800	1	1700	1	1800	5
1700	2	1900	1	1800	4	1900	4
1800	1	2800	1	1900	1	2000	1
1900	2			2000	3	2100	4
2000	2			2100	1	2200	2
2100	1			3000	1	2300	1
2200	4					2400	4
2300	1					2500	2
2400	1					2700	1
3000	1					2800	2

TABLE IV (*cont.*)

16–20 years		*21 or more years*	
Salary	*Number*	*Salary*	*Number*
$1400	2	$1400	1
1800	1	1500	2
1900	1	1600	2
2000	1	2000	4
2100	1	2100	1
2200	1	2200	1
2300	1	2300	1
2400	1	2400	3
2800	2	2500	1
3100	1	2600	3
		2700	1
		2800	1
		2900	1

CITY AND VILLAGE HIGH SCHOOLS

1 year		*3 years*		*4 years*		*5 years*	
Salary	*Number*	*Salary*	*Number*	*Salary*	*Number*	*Salary*	*Number*
$1500	3	$1300	1	$1400	1	$1500	1
1800	1	1400	2	1500	3	1600	1
2 years		1500	3	1600	2	1700	1
Salary	*Number*	1600	3	1700	4	1800	3
$1300	1	1800	2	1800	2	1900	2
1400	2			2000	1	2100	1
1600	2			2200	1	2300	1
1700	3			2300	1	2600	1
				2400	1		

6 years		*7 years*		*8 years*		*9 years*	
Salary	*Number*	*Salary*	*Number*	*Salary*	*Number*	*Salary*	*Number*
$1400	3	$1400	2	$1200	1	$1400	1
1500	6	1500	2	1300	1	1500	1
1600	3	1600	2	1400	1	1700	3
1800	3	1700	2	1600	2	1800	1
1900	4	1800	1	1700	2	1900	1
2000	4	1900	1	1800	1	2800	1
2100	1	2000	1	1900	2		
2200	2	2100	1	2000	2		
2800	1	2200	3	2100	1		
		2300	3	2200	4		
		2500	1	2300	1		
		2600	1	2400	1		
		2700	1	3000	1		

10 years		*11–15 years*		*16–20 years*		*21 or more years*	
Salary	*Number*	*Salary*	*Number*	*Salary*	*Number*	*Salary*	*Number*
$1400	2	$1400	1	$1400	2	$1400	1
1500	1	1600	1	1800	1	1500	2
1600	1	1700	1	1900	1	1600	2
1700	1	1800	5	2000	1	2000	4
1800	4	1900	4	2100	1	2100	1
1900	1	2000	1	2200	1	2200	1
2000	3	2100	4	2300	1	2300	1

TABLE IV (*cont.*)

10 years		*11–15 years*		*16–20 years*		*21 years*	
Salary	*Number*	*Salary*	*Number*	*Salary*	*Number*	*Salary*	*Number*
2100	1	2200	2	2400	1	2400	3
3000	1	2300	1	2800	2	2500	1
		2400	4	3100	1	2600	3
		2500	2			2700	1
		2700	1			2800	1
		2800	2			2900	1

and (2) size of the school system. In the following tables and figures, data are given concerning the salaries paid teachers of varying experience.

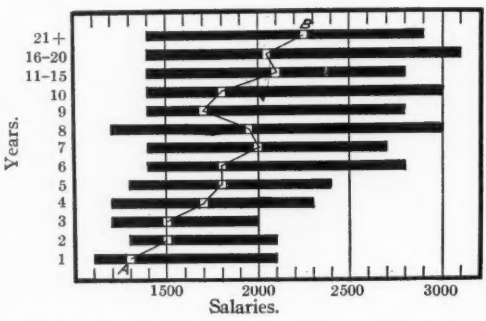


FIGURE 1.—COUNTY SALARIES VERSUS YEARS OF EXPERIENCE

A rough measure of the effect of the size of the school system is to be had by comparing county with city high schools.

In Table IV are tabulated the years' teaching experience, salaries, and numbers of teachers receiving each salary. All salaries were rounded off to the nearest hundred dollars.

In Figures 1 and 2 these data are represented graphically. The line *AB* connects the median salaries for each group.

It will be noted that in each case the minimum remains close to the left edge of the chart, some teachers apparently remaining at approximately the same salaries for their entire careers. The maximum, on the other hand, increases as the experience increases, gradually in the case of county teachers, and much more rapidly in the case of city teachers. The median also increases much more rapidly for the latter than for the former.

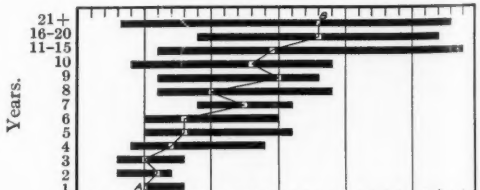


FIGURE 2.—CITY SALARIES VERSUS YEARS OF EXPERIENCE

These same data are plotted in a slightly different manner in Figure 3. Here are shown maximum, median, and minimum salaries against years

of experience for the two groups. The dotted lines represent county teachers, and the solid lines city teachers. It is interesting that the maximum for county teachers remains above or near that for those in the cities until the ten-year mark is passed.

These data and curves, however, do not in themselves show the entire picture. In the next two figures are shown the number of individuals in each group according to salary or experience. Curve *A* in each represents city teachers, *B* county, and *C* totals.

If experience were the only factor controlling salaries, these two curves should be parallel. The marked divergence in the right half shows that there are many teachers of long experience, but only a few with high salaries. The inference is, of course, that experience alone will not insure salary increases.

In the previous study mentioned above (*2*), the distribution of experience teaching chemistry was tabulated. In this study, total years of teaching experience was the basis. It is interesting that these two curves differ greatly. For those concerning whom the writer had data listing both items a comparison was made. Of the county teachers, 33 had been teaching chemistry during all their teaching experience, while 128 had not. Twenty of the thirty-three were engaged in their first year of teaching. Of the city teachers, 32 belonged in the first class, while 76 had been teaching many more years than they had been teaching chemistry.

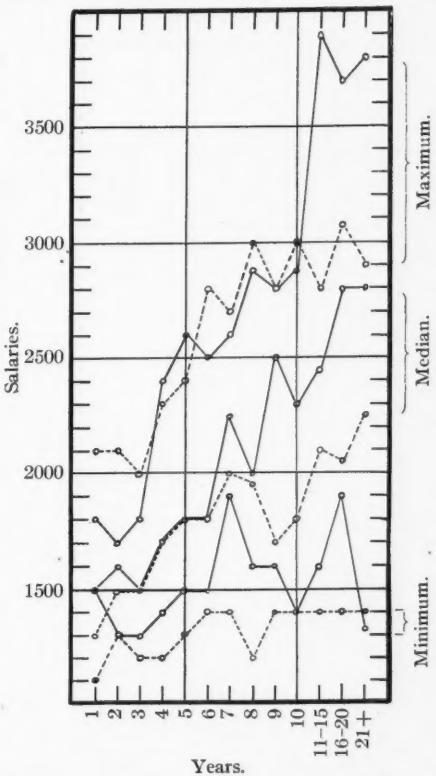


FIGURE 3.—MAXIMUM, MEDIAN, AND MINIMUM SALARIES VERSUS YEARS OF EXPERIENCE
—— City ---- County

Discussion of Results

The question now arises, what are the prospects facing a student con-

sidering the teaching of high-school chemistry as a profession. Dr. Anderson (*1*) has answered that the beginning salary will be fairly low. The data given above indicate that in general the salary will rise, as experience is gained, more rapidly if a position is secured in a city system. At the outset the maximum and minimum salaries are very close together, but as time goes on they differ widely. This represents the working of the effects of ability, personality, professional activity, size of the school, etc., which cannot be measured quantitatively. The outlook would seem

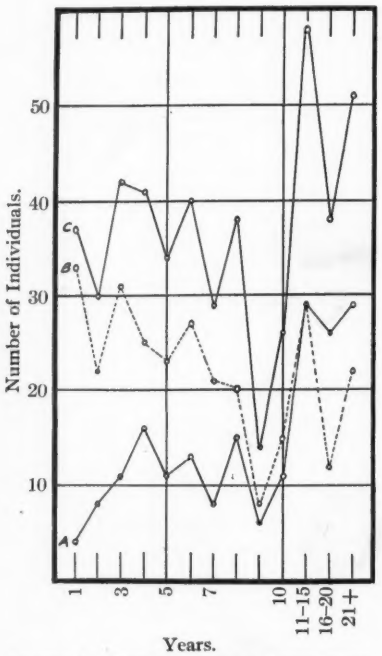


FIGURE 4.—DISTRIBUTION OF EXPERIENCE
A—— City *B*- - - - County *C*—— Total

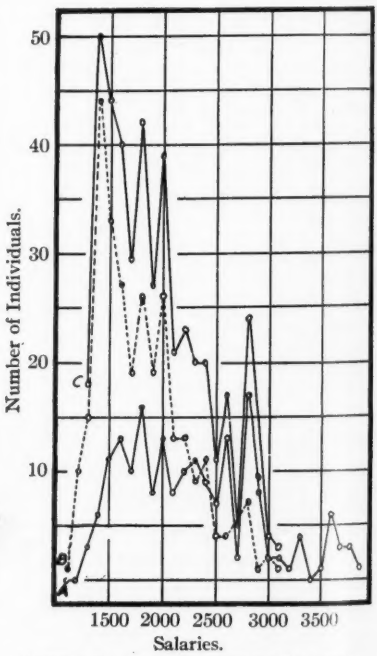


FIGURE 5.—DISTRIBUTION OF SALARIES
A—— City *B*- - - - County *C*—— Total

to be, therefore, that some few, probably individuals of exceptional ability or good fortune, can look forward to advancement to relatively high salaries, while mediocrity in general is penalized by little or no salary increase. Much has been said indicating that the teaching profession is underpaid. The writer wishes to let these data speak for themselves. Some chemistry teachers in Ohio are very well paid. Others are not paid an amount commensurate with their investment in time and money. The medians seem to run along a fairly satisfactory level. There are wide

variations in the amount and character of the training of the teachers, and also similarly wide variations in the stipends. The writer feels that the chances are that in general ability receives its reward, although nothing in these data will either prove or disprove this opinion.

Literature Cited

(1) ANDERSON and STUBBS, "Salaries of Inexperienced Teachers," *Educ. Research Bull.*, **8**, 289 (1929).

(2) E. W. PHELAN, "The Status of Chemistry and the Chemistry Teacher in the Ohio High Schools," J. CHEM. EDUC., **6**, 2198 (Dec., 1929).

Views of Professor Fritz Haber on German and English Chemistry. An interesting comparison of German and British chemistry is contained in a report of an interview with Professor Fritz Haber, the great German scientist, which the *Manchester Guardian* publishes from its scientific correspondent. Professor Haber, one of whose great achievements was in the commercial synthesis of ammonia and who was mainly responsible for the preservation of German laboratories after the war, is described as the "Stresemann of German science."

The methods of the chemical industry which was founded in England in the first half of the last century, he says, were mainly empirical, and works managers did not bother much about the nature of the processes they used so long as results and profits were obtained. This attitude was conserved by the enormous success of empiricism at the beginning of the Industrial Revolution in England, and has persisted to some degree ever since. About 1850–60 Germany began to send men to learn the English technical chemical processes. These were men of education and initiative, and they returned to Germany and started new chemical industries there. Thus, from the beginning, many of the chiefs of the new German industries founded in the 'sixties were scientists first and industrialists afterward. There has never been any sharp separation in Germany between scientists and business men in the chemical and other important industries.

In Britain industrialists have always had a tendency to regard the scientist as a doctor, some one called in to prescribe in times of difficulty, and not incorporated as a partner in the concern. The independence of the scientist, some one who takes fees but is not salaried, has been adjusted with English social ideas.

The pressure of international circumstances forces Germany to be scientific. She has no colonies to engage her interest and attention. Britain always has the organization of her Empire to distract her from the problems of internal organization of science and industry. Indeed, for the British it is more profitable to know how to rule other countries than how to superorganize her own. If Britain had no colonies she would have nothing to distract her from the intensest efforts of rationalization.

In Professor Haber's opinion, Britain has a long period of comparative prosperity in front of her. The British blame the Government for their difficulties, and yet to other nations British Governments seem extraordinarily able. The British discuss only the bad points in their industrial and colonial affairs, so that the nineteen good ones are forgotten in the clamor over the deplorable twentieth. British conditions seem to be comparatively happy to those who have to struggle with such intractable problems as the expansion of population where there is no room for it, as in Germany.—*Chem. Age*

Correspondence

DOES EDUCATION PAY?

DEAR EDITOR:

I have recently been interested in reading your editorial entitled "Does Education Pay?" While I agree with you in the main, I believe that possibly you overlook one reason for the stress placed on this idea.

We have in this country gone so far in our thinking that we say not only must we provide equal opportunities for education for every child, but that every child shall be forced to take advantage of these opportunities. This puts into our schools a large number of children who are unhappy in a school environment and also a number of children whose parents are not heartily in sympathy with such forced education.

This situation leaves our school teachers, trustees, and truant officers in a difficult position. Either we may force this attendance or we may try to make education for this group as attractive as possible. The whole question as to whether such children should be in school or at work is beside the present question. One of the few ideas which we have found which makes any appeal is that education has a monetary value. I think we are faced with a situation which we do not know how to meet and this is our present substitute, even though we admit the fallacy of our argument in general and when carried out over a long period of time.

S. D. LAW

EXETER UNION HIGH SCHOOL
EXETER, CALIFORNIA

"LIVE" CHEMICAL MUSEUM EXHIBITS

DEAR EDITOR:

A recent contributor to your JOURNAL distinguishes between "dead and "live" chemical exhibits (*1*). He considers a collection of specimens in neatly labeled bottles or jars to be "dead." From a museum standpoint there should be no disagreement with him. Exhibits are described by him, however, as "live" if the specimens are grouped to illustrate synthesis. Why should they be considered "live?"

In 1800, Count Rumford, founder of the Royal Institution of Great Britain, published a prospectus for that institution stressing the importance of working exhibits (*2*).

> The completest working models or constructions of the full size will be provided and exhibited in different parts of this public repository of all such new mechanical inventions as are applicable to the common purposes of life.

Thus the value of "live" exhibits were fully appreciated 130 years ago by Count Rumford and his proposals to insure that character would apply almost equally well today.

Unquestionably, working models make "live" exhibits in a museum sense. Why, then, not animate synthesis exhibits by working models?

The writer, intending this letter to be in the nature of constructive criticism, hastens to present a possible design for a true "live" chemical exhibit.

A shadow box is equipped with many tiny flash-light bulbs arranged in such manner as to indicate structural formulas bearing atomic symbols. These lights, turned on by means of a snap switch, operate a somewhat modified sign-flashing device. The slowly turning sign-flasher first lights a series of bulbs forming the outline of the structural formula for the basic material used as a starting point in the synthesis. Connections made by the sign-flasher successively light bulbs showing the actual process of synthesis exactly as it is accomplished by means of the chemical processes through which it passes. Atoms substituted for others during the process of manufacture are indicated by lights switched off and replaced by others bearing the proper new symbol. The evolution of aspirin from carbolic acid could, by this means, be followed step by step.

Very sincerely yours,

ERNEST E. FAIRBANKS

MUSEUMS OF THE PEACEFUL ARTS
24 WEST 40TH STREET
NEW YORK CITY

(1) SPIERS, C. H., "A Chemical Museum Exhibit," J. CHEM. EDUC., **6**, 730–2 (Apr., 1929).

(2) Complete Works of Count Rumford, Vol. IV, collected and published by the American Academy of Arts and Sciences, **1875.**

Sodium Sulfide in the United States. The growth in domestic production of sodium sulfide from 24,682 tons in 1921 to 46,494 tons in 1927 has enabled the American chemical industry to supply 90 per cent of domestic requirements of this commodity. The remainder is supplied by imports which averaged about 4500 tons in 1927–28. The increased consumption corresponding to the above figures is attributable to greater activities in the chief consuming industries for this commodity, including manufacture and application of sulfur colors, tanning, mining, and rayon.

Since sodium sulfide is made from sulfates, chiefly of barium and sodium, the important changes which are affecting the availability of these salts on the American market must be considered in understanding the economics of the question. Among these are the establishment and growth of the American barium chemical industry, of which sodium sulfide is a co-product, the synthetic nitrogen and hydrochloric acid industries which tend to make the by-product nitre cake unnecessary.—*Chem. Age*

Chemical Digest

PERSONALITY DEVELOPMENT IN STUDENT-TEACHERS

Were it possible to eliminate personality defects by a course of training, many a young teacher now lost to the profession because of "lack of forcefulness, sociability, or a business-like manner" would be retained, according to William F. Bruce writing in the *Journal of Educational Research*.[1] While it is granted that strength of character and enriched personality are among the choice attainments of most college-bred individuals, nevertheless there *are* those who have passed all requirements for college graduation and still lack the elements of personality requisite for success as teachers.

Lancelot, in *Educational Administration and Supervision* (May, 1929), describes a method used in Iowa whereby essential traits of personality are cultivated in student-teachers. Readings and discussions in this training course emphasize the importance of certain personality traits for success in teaching. Each student is subjected to individual analysis which discovers any weaknesses, and a list of activities is provided that is considered suitable to counteract such defects. Each student thus aims directly to overcome lack of friendliness, lack of ambition, or other weak traits while, at the same time, each trait is being built up as a separate unit by the individual. Lancelot is convinced that in sheer social value training in personality is worth more than the study of any combination of social sciences that can be named.

Bruce[1] points out the consequences of a training which centers on vocational success, and which is preferred to a training in "social ideals as a way of finding the aim of life and of education." He believes that the method of direct approach will itself interfere with the character development desired in that the learner becomes self-conscious and this attitude blocks his progress toward the enrichment of his personality. Then, too, he finds that a more serious danger appears when we consider that a direct attack on one's personality is likely to bring in its train not only self-consciousness, but also selfishness and egotism. Furthermore, in the Iowa plan, personality improvement itself tends to become an isolated and abstract ideal leading toward a narrow and over-emphasized loyalty to itself.

Having pointed out some of the unfortunate tendencies in the personality development movement, Bruce now offers some positive suggestions:

[1] W. F. Bruce, *J. Educ. Research*, **21**, 191–202 (Mar., 1930).

A constructive program of character building must provide the needed and purposeful social activities which will enable the student-teachers to engage in these activities with whole-souled directness. An indirect approach must be devised as a means to directness.

New purposes grow, or are created, only in the midst of social action. One phase of a social experience is the evaluation of the consequences of that experience. If a person carefully evaluates the results of his action as he pursues his purpose, he will also be modifying his original aim. Through deliberate reflection on the social consequences he constructs a new purpose. His character is changed as he evaluates intelligently and reasonably. Worthy purposes arise out of intelligent experiencing.

But intelligent evaluation of experience can scarcely occur unless the student-teacher has some standard of ethical ideal. The person must be able to tell when he has attained desirable results.

Constructive, consistent character-building cannot proceed unless one has a point of view or aim in life. This need for a unifying aim or social philosophy is easily forgotten in the midst of building a personality development program.

The most liberal functioning of intelligence can and should be encouraged in every stage and phase of character training. No habits should be formed except for a purpose. Habits so formed are intelligent activities. Mechanical methods produce habits which are so dissociated from each other that even reason cannot integrate them. But if reason is given a fair chance from the beginning, integration will be, in a large measure, a continuous characteristic of the system of habits as it is developed.

Personality is, at best, a unity which is constantly being achieved and reformed in such a way that the contribution of past experience (habitual activity) cannot be distinguished from the creative modification (intelligent activity) which must occur in the solution of the new problem in ethics presented by the new occasion of the present moment. The essential feature of character formation is the liberation of intelligence in the pursuit of specific ends.

When intelligence is given free play in the teaching of ideals no narrow loyalty to this ideal or that ideal is established. Each ideal as it is formed becomes a member of the *whole* point of view, modifying the aim of life and being modified at the same time. So the student-teacher learns to integrate his life and regulate it in the light of one system or point of view which is organized in such a way as to include all the aims of life.

The method of personality improvement adopted in teacher-training institutions should concentrate upon the construction and attainment of a central aim for education. In the direct pursuit and accomplishment of this task, the faculty and students may lose the kind of self-consciousness that interferes so seriously with their effective social action, and in so doing may step out into a kind of direct, whole-souled activity which will actually result in the attainment of superior personality without danger of feeling that superiority.

R. M. P.

TEACHING OF CHEMISTRY FROM A FACTORY VIEWPOINT*

The vocational outlook of the student in chemistry has broadened within twenty-five years from that of a teaching position, or a minor place incidental to certain industries, to the present manifold possibilities of employment in chemical works where the student's opportunity is limited only

* L. F. NICKELL, *Trans. Ill. Acad. Sci.*, **22**, 377–80 (April, 1930).

by his own native ability, personality, and chemical training. Within this same length of time the language of chemistry has been translated into the language of the balance sheet, and thus it is no longer a foreign tongue to bankers or to the general public. In order that the chemical plant may manufacture at low cost it must be manned with technical men. The supply of chemists and chemical engineers of proper caliber to meet these demands is far enough short at present to prove a handicap to the industry. Technical schools and universities are taking measures to meet this situation but only a beginning has been made and much more remains to be accomplished.

The activity of the chemically trained man finds outlet in the following ways: (1) research, (2) analytical control, (3) supervision of manufacturing operations, (4) engineering, (5) executive, (6) sales. Men of widely divergent traits may find success in one or the other of these activities.

But for all—a thorough knowledge of the fundamental laws and principles of chemistry and physics is an absolute necessity. The teaching of such fundamental laws and principles must be accompanied by a sufficient amount of fact to amplify, explain, and fix them indelibly in the student's mind. At best, a technical course can only supply a man the tools with which to work. The graduate is not a finished product; he must always continue to be the student and the investigator; his curiosity must always be alive and his imagination must ever be keen and active; but these avail him little if he cannot solve his problem when he meets it and recognizes it; and it is a grievous thing to find how often technical men of real accomplishment lack the ability to apply fundamentals such as gas laws, thermal laws, vapor pressure, mass action, or centrifugal force to the problems confronting them.

The courses which teach these fundamental laws too often fail to receive the attention they should. The student who becomes well grounded in fundamentals should be trained in resourcefulness in applying them. He should learn to make use of such imagination as he possesses, and should acquire reading habits that will enable him to gain information on his own account.

The teacher in chemistry would do well to follow the example of the English teacher in giving outside reading assignments to students and requiring reports on such assignments. . .What is he to do in the factory if the problem confronting him can not be found in a textbook?

The student should acquaint himself with numerous processes outlined in industrial chemistry texts, but such acquaintance should be gained by outside reading. Class time may well be used to discuss relative merits of different processes for a given product, under a given set of conditions, or for designs used for an installation to manufacture a certain product, such designs to be criticized and discussed by the class.

I put first in importance teaching the student fundamentals; second, teaching him to think. He will have to do it when he enters the factory. He should have the habit when he leaves school.

The course should awaken in him the ability to use his leisure time pleasantly and agreeably in some way other than reading chemistry, the *Saturday Evening Post*, and the daily newspapers. There should be some place, however small, in his curriculum where he can at least get a glimpse of some of the humanities, economics, sociology, law, literature, music, art, or whatnot. Let him not lose his ability to become interested in something besides his profession. It will make him a better chemist, a more useful citizen, and a happier man.

R. M. P.

X-Rays Lay Bare Secrets of Crystals. Because X-rays do not bend when they hit a solid object, but either pass straight through or stop dead, they have become one of the most important of the tools of modern physics, laying bare the secrets of crystals and showing how atoms are arranged in molecules. The usefulness of these invisible radiations was discussed recently in a radio talk, given over the Columbia Broadcasting System under the auspices of *Science Service*, by Sir William H. Bragg, director of the Royal Institution of Great Britain and one of the world's leading physicists.

Radio waves, light waves, and the waves of X-rays, Sir William reminded his hearers, are all members of the same family, so far as their fundamental nature is concerned. But radio waves will turn and bend and go around obstacles, while light and X-ray waves will not deviate from a straight line.

"Light waves would be of no use if they behaved like that," he continued. "If they did we should swim in a sea of light but it would be much the same in all directions. Whichever way we looked we should be receiving light from all the surrounding objects; we should have to exercise care even to sort out whether a thing was in front of us or behind. We must have light that turns corners as little as possible. Even in radio transmission when a so-called 'beam' is wanted—a ray which will keep more or less straight without spreading—short waves of twenty or thirty meters only are employed. Now small details can only be kept distinct when the rays of light from them keep very straight. For this reason there is a limit to the smallness of things that may be seen by the aid of ordinary light; not even with the aid of the microscope can that limit be overstepped. In the same way it might be possible to detect the presence of a mountain by its effect on radio transmission; but radio could not be used to find a house or a tree.

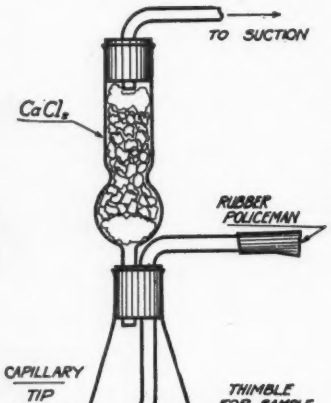
"But the X-rays enable us to see, if I may use the word, what light cannot show us. Of course, we have to replace our eyes by specially made instruments. And when we use the X-rays we find ourselves in a new world which is always about us, which has to do with the structures of ourselves and all our surroundings, and with the way in which those structures are fitted for their work; this new world has hitherto been hidden from us.

"First of all, we are struck with the constant tendency in Nature to arrange in order the atoms of which all things are made. The carbon atoms which make up the diamond are arranged in a beautifully simple pattern, one of the most regular of all the patterns we find in crystals; and no doubt we have here the reason why the diamond is so hard. When it is rubbed against other substances in which the forces that tie the atoms together are less strongly and systematically combined, it is the atoms of the second substance that must shift, while the diamond remains unchanged.

"With the aid of the X-rays we can peer down into the pattern of the ice crystal, so fine in detail as to be far beyond the power of light to examine; and we see the atoms of oxygen and hydrogen arranging themselves to make six-sided figures which, when multiplied enormously, make the crystals of snow and ice with which we are familiar."—*Science Service*

ABSTRACTS

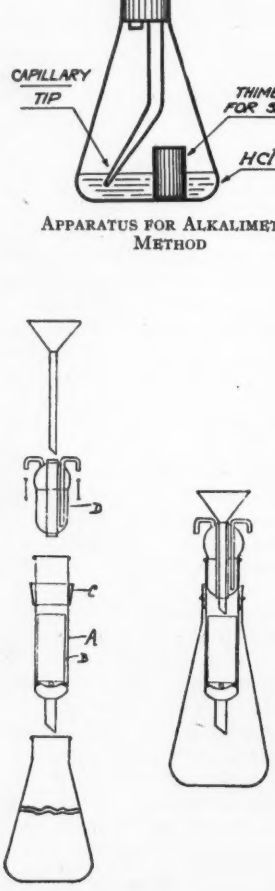
APPARATUS, LABORATORY PRACTICE, AND DEMONSTRATIONS



APPARATUS FOR ALKALIMETER METHOD

Determination of Carbon Dioxide in Carbonates. W. W. SCOTT AND P. W. JEWEL. *Ind. Eng. Chem., Analyt. Ed.*, **2**, 76 (Jan., 1930).—The apparatus is shown in the figure. The weighed sample is placed in the thimble and after weighing the apparatus, the thimble is overturned by shaking. The inlet tube is closed and the outlet is open. When the reaction has subsided the inlet tube is attached to a purification train of calcium chloride and soda lime and air drawn through at the rate of two bubbles per second for 15 min. The loss in weight represents CO_2 present. Weight of sample is about 0.5 g. and about 15 cc. HCl. The method is accurate to about 0.1%. D. C. L.

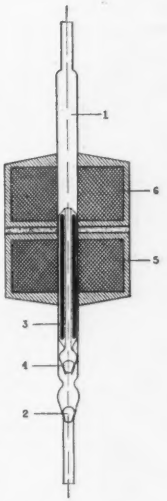
Sedimentation Tube for Mechanical Analyses. P. D. TRASK. *Science*, **71**, 441–2 (Apr. 25, 1930).—The sedimentation tube consists of a glass tube which fits into a glass cup by a ground joint as illustrated. A hole in a wood block may be used as a support or the cup may be made with a square base. Sediments are transferred from a dispensing tube to the sedimentation tube. Silts and clays are decanted from the tube, the cup in which the sands have collected is removed, and the sands readily washed out. G. H. W.



Apparatus for Filtration in the Warm of Saturated Solutions. S. H. BERTRAM AND W. A. VAN MEURS. *Chem. Weekblad*, **27**, 7–8 (1930); *Analyst*, **55**, 300 (Apr., 1930).—*A* is a glass jacket containing a filter-thimble *B* (25 × 70 mm.) resting on 4 glass projections which may be fixed in the neck of an Erlenmeyer flask by means of the stopper *C*. A little solvent is warmed in the flask, the condenser *D* inserted in the ground-glass joint at the top of *A*, and the solution to be filtered poured into the thimble by means of a funnel passing through the center of *D*. The solvent vapor in *A* acts as a jacket for *B*, and the drops of condensate serve to wash the residue. R. L. H.

New Types of Sensitive Silica Manometers. B. LOCUSPEISER. *J. Sci. Instruments*, **7**, 145–51 (May, 1930).—The principles of construction of two types of sensitive silica manometers are described. The deflection, to a close degree of approximation, is proportional in one case to the pressure, and in the other to the logarithm of the pressure. Photographs of the instruments and details of technic involved in their construction are included. R. L. H.

An Electro Magnetic Pump. H. ROSENBERGER. *Science*, **71**, 463–4 (May 2, 1930).—The diagram shows the pump in cross-section.



The pump cylinder (1) is a glass tube which has a carefully ground valve (2) at its lower end. The piston (3) consists of two tubes with a soft iron core fused between them. The lower end of the piston has a valve (4) which is identically the same as the cylinder valve (2). Both valves close by gravity. The pump cylinder is surrounded by a lower solenoid (5) and an upper solenoid (6). Both solenoids are hooked up in separate circuits. By means of a three-pole, automatic, mercury switch actuated by a rocking device, the electric current flows through the solenoids periodically in such a way that they switch on and off, one after the other, with an intermediate state in which both solenoids are magnetized for a short time. Thus a magnetic field is created inside the solenoids. The center of this field travels up and down periodically. The iron core inside the piston is attracted into the center of the magnetic field. The piston moves up and down continually, like the plunger of any pump. The up-stroke of the piston opens the cylinder valve (2) and closes the piston valve (4), while the down-stroke closes the cylinder valve and opens the piston valve. By this means, any fluid may be circulated or transferred. G. H. W.

Possible Sources of Error in pH Determinations. L. FLETCHER AND J. B. WESTWOOD. *Chem. & Ind.*, **49**, 201T–203T (Apr. 25, 1930).—This is not an exhaustive survey of the subject, but deals with a few sources of error noted by the authors. Temperature differences of more than 1 °C. in different parts of the hook-up and at different times are to be avoided. Several hours may be required for equilibrium to be reached at each electrode after each change in temperature. Methods of preparing the hydrogen electrodes and different sources of hydrogen gas are discussed. E. R. W.

Fire Kindling. J. R. LUNT AND D. E. HALEY. *Sci. Educ.*, **14**, 551–5 (Mar., 1930).—The following five interesting experiments are described: use of bow and drill in making fire (one of the boy scout methods); use of flint and steel; kindling fire with a lens; using chemical action to start a fire; how the first chemical matches were made. The experiments are described in language easily understood by beginners in chemistry. J. H. G.

TEACHING OBJECTIVES, METHODS, AND SUGGESTIONS

Are We Teaching the Right Chemistry? F. B. KENRICK. *Can. Chem. Met.*, **14**, 45–6 (Feb., 1930).—The impression received by the author of the numerous articles published in the JOURNAL OF CHEMICAL EDUCATION is that they present a mass of complicated confusion. The following principles are submitted which are supposed to lead to the essentials of scientific training: (1) for laboratory work, whatever happens in the laboratory must be right if it is wrong; (2) all combinations of words, whether printed or spoken, whether definitions or statements of laws or hypotheses, must be interpreted in terms of laboratory operations and observations. The author explains in detail the meaning of these two principles. R. L. H.

A Tonic for a Run-Down Chemistry System. A. WESTALL. *Trans. Ill. Acad. Sci.*, **22**, 391–401 (Apr., 1930).—The author realized that a teacher could know the subject matter far better than the subjects—the pupils, and that while pupils differ in I. Q. from dull to near genius, they differ even more in special abilities, special aptitudes, and peculiar interests. Assignments accordingly were made so elastic that they would take care of *individual differences*. The work is illustrated in this article by an assignment on carbon. Details of the complete plan are given including reference material, points, contracts, reports, scrapbooks, advertisements, experiments, class discussions, and examinations. [For assignment on nitrogen by the same author see J. CHEM. EDUC., **6**, 1528–34 (Sept., 1929).]

The success of this teaching project was shown by the fact that in grading "it was not possible to follow the normal marking curve since each student seemed fired with enthusiasm and worked harder than 'A' students had formerly."

Some of the advantages enumerated for this type of assignment are: (1) it appeals to every type of pupil; (2) independent outside work increases the pupil's reliance on his own efforts; (3) properties and uses of substances are more easily remembered since they are associated with every-day life, and thus are far more interesting; (4) pu-

pils learn something of the art of advertising; (5) in making scrapbooks, posters, and advertisements, the pupils learn the importance of neatness and clever color schemes. R. M. P.

Lesson Assignment on Carbon. See abstract on **A Tonic for a Run-Down Chemistry System** above.

Chemistry for Fun. R. E. DUNBAR. *Sci. Educ.*, **14,** 517–8 (Mar., 1930).—Realizing that the student of chemistry wishes very often to experiment in the laboratory for fun, without the requirement of writing up the experiments and preparing for a quiz, also that it is necessary often to prepare stunt programs for chemistry and science clubs, for assemblies, and similar gatherings, the author has prepared twelve titles of books and twenty-nine other references which will furnish the teacher and student with suitable material. J. H. G.

Programs for Chemistry and Science Clubs. See abstract on **Chemistry for Fun** above.

High-School Essay Contest. See item on **American Association for the Advancement of Science** on page 1963.

Statistical Data 1928 for Chemical Instruction. F. HOFMANN. *Z. phys. chem. Unterricht*, **43,** 75–9 (Mar.-Apr., 1930).—Author lists and discusses statistical information concerning (1) world production and consumption of coal, iron, steel, petroleum, non-ferrous metals; and (2) the German lime and sulfuric acid industry. L. S.

Teaching of Chemistry from the Factory Viewpoint. L. F. NICKELL. *Trans. Ill. Acad. Sci.*, **22,** 377–80 (Apr., 1930).—See digest on pages 1939–41 of this issue of the J. CHEM. EDUC.

Curriculum Construction in Chemistry. See this title below on this page.

How State Academies of Science May Encourage Scientific Endeavor among High-School Students. See this title on page 1945.

The Results of the Experiment with Eastman's Classroom Films. See this title on page 1956.

Research Method of Teaching Science. See this title on page 1945.

Diagnostic and Remedial Technics for College Freshmen. See this title on page 1945.

ADMINISTRATIVE PROBLEMS AND DEVICES; CURRICULA

A New Curriculum at Toledo. H. J. DOERMANN. *Assoc. Am. Coll. Bull.*, **16,** 280–2 (May, 1930).—For a number of years the University of Toledo has been operating on the junior-senior college plan of organization whereby under careful guidance students completing four years of high school and two years of college would round out a general or liberal education. The manner in which specific content was given is outlined here for both the junior and the senior college. G. O.

Curriculum Construction in Chemistry. M. D. ENGELHART. *Sci. Educ.*, **14,** 518–22 (Mar., 1930).—The process of curriculum building in chemistry is a difficult one. The author offers a plan of first determining the ultimate objectives, those activities conditioned by a study of chemistry, and in two ways, one by consulting textbooks and the literature in general, and the other by consulting and receiving the opinion of authorities in the field of chemistry. Then the activities should be classified, using the present participle, as, *Reading popular magazine articles pertaining to atomic structure.* There should then follow a determination and classification of immediate objectives, those abilities necessary for the performance of the activities labeled ultimate objectives. The doing of appropriate tasks on the part of the learner, and the following out of requests made by the teacher are then considered in connection with the foregoing. In recapitulation, each learning exercise should stimulate the pupil to learning activity so that he acquires an ability, or abilities, which will be useful in performing an activity, or activities, in later life. J. H. G.

Some Problems Confronting the Teachers of Elementary General Chemistry. *Rep. New Eng. Assoc. Chem. Teachers*, **31,** 167–78 (May, 1930).—Three factors have profoundly affected the status of our courses. The industrial and economic applications of chemistry have developed at such a tremendous pace that the amount of such material one wishes to include has increased very greatly. A second factor is the rapid development of theoretical concepts. Thirdly there has been a great increase in the number of students who have no intention of becoming chemists. O. C.

A Plea for the Genius. See this title on page 1958.

Premedical Requirements in Chemistry. H. T. CLARKE. *J. Assoc. Am. Med. Coll.*, **5,** 134–7 (May, 1930).—Instruction in biochemistry alone is not sufficient chemical instruction for medical students. To meet the present increasing importance of

chemistry in medicine, the author favors increasing the premedical requirements from the generally accepted eight hours to eighteen hours, of which nine credit hours should be in laboratory work. Throughout these courses the quantitative aspect of chemistry should be emphasized. Elective courses might well be utilized in strengthening the premedical student's grasp on fundamental chemistry so that he will profit more from his instruction in biochemistry. H. H. K.

Relationship of the New Physics and Physical Chemistry to the Curriculum. See this title on page 1959.

Language Requirements for Doctors of Philosophy. See this title on page 1957.

Research Method of Teaching Science. J. M. ANDERS. *Assoc. Am. Coll. Bull.*, **16**, 223–33 (May, 1930).—A readjustment of the college curriculum to bring about the research method of study rather than an absorption of ready-made facts by the students is of pressing importance since the recognition of the growing need of men trained in research has been one of the chief causes of the expansion of the scientific side of education. Just how active a part the college should play depends upon the fitness of its student body. Close supervision of the budget will obviate undue wastage. G. O.

The Place of Research in the Undergraduate College. A SYMPOSIUM OF THE JOINT COMMITTEE ON RESEARCH IN COLLEGES. *Assoc. Am. Coll. Bull.*, **16**, 198–222 (May, 1930).—The members of the joint committee, composed of representatives of the Social Science Research Council, the National Research Council, the Am. Council on Education, the Am. Assoc. for the Advancement of Science, the Assoc. of Am. Colls., the Am. Assoc. of University Professors, and the American Council of Learned Societies, seek to build up an American program of education based on the research idea. These articles attempt to show what would be some of the effects of an educational system designed to cultivate the research habit of mind.

Part I. MAYNARD M. METCALF. Would have the program begin with the pre-kindergarten child in the home. Some of the effects of such a system are: (1) education so attained would increase the capacity of the pupil far more than it does today. (2) The period of training necessary for the attainment of sound judgment and productive ability would be shortened, say two years in pre-college work. (3) It would permit entrance into college at an earlier age or permit a wider content of study in precollegiate study, the latter being preferred rather than the former. (4) It would entail greater cost, more teachers, and buildings so as to deal with pupils in small groups. Expensive as that would be, he suggests that it could be paid largely from the money saved by abolishing war and preparation for war. "If America alone, without international coöperation, should cut her war expense in half, she would soon so far surpass other nations in wealth, prosperity, and equipment that no nation or group of nations would even consider attacking her."

Part II. WALDO G. LELAND, secretary Am. Council of Learned Societies, believes that the outlook for research in the undergraduate colleges is much brighter than probably at any time for the opportunities and the materials are not lacking if only the teachers and students take advantage of them. Great advance has been made by learned societies in late years by surveying fields of research, in suggesting professional subjects for investigation, in coördinating the work of different scholars, in organizing coöperative undertakings, and in promoting the preparation of essential tools and aids.

Part III. EDWIN B. WILSON, president of Social Science Research Council makes a plea that some way be found to enliven the teaching of social sciences, for there is plenty of field work in every college town.

Part IV. VERNON KELLOGG, permanent secretary, National Research Council, sums up the why of research.

Part V. D. A. ROBERTSON, Ass't Director Am. Council on Education takes the stand that higher education in the U. S. would advance if a larger number of institutions would stimulate the spirit of research in all students and teachers.

Part VI. MARIAN P. WHITNEY, Chairman Committee for Encouragement of Research, Am. Assoc. of Univ. Profs., asks the question: "How can America hope to earn or keep a place among the nations who are the carriers of civilization if creative scholarship is driven from our colleges and productive workers are driven into research institutes or graduate colleges shut off from contacts with the younger generations."

The symposium closes with a memorandum by J. L. McConaughy on research at Wesleyan University. G. O.

Diagnostic and Remedial Technics for College Freshmen. H. J. ARNOLD. *Assoc. Am. Coll. Bull.*, **16**, 262–79 (May, 1930).—In this article the writer proposes to present some practical suggestions for dealing with the problem of college students' deficiencies

in certain tool subjects with the hope that some of the methods may prove helpful. The suggestions are grouped under two general headings: (1) a plan of procedure for colleges including suggestions for dealing with student deficiencies in English composition, arithmetic, and reading; (2) the evidence of the value of remedial instruction. The plan of procedure includes the determination of essential skills, diagnostic testing, remedial procedures, the re-test, and a college diagnostician. G. O.

The Function of a Research Bureau in a State Department of Education. W. W. COXE. *J. Educ. Research*, **21,** 7–14 (Jan., 1930).—In a recently organized movement such as that of research in state departments of education it is important that an effort be made to define functions. A clear definition of functions will help to remove causes of misunderstanding among workers and will render assistance to state superintendents in the organization of research divisions in their departments.

The author gives the following summary: "A research bureau has a vital function to perform in a state department engaged in the formulation of constructive, progressive, educational policies. Such a bureau will stress administrative research, both engaging in such studies and directing others. Secondarily, it will engage in supervisory and instructional research, and act as a clearing house and reference center. A bureau of this nature should encourage a more scientific study of educational problems, not only in the state departments but throughout all the schools of the state. Its problems are generally the more extensive and complicated ones requiring extended study and the direction of a technically trained personnel. Also, the problems must be of vital importance to educational practice. The final summaries and interpretations must be simple and practical, resulting in policies which bring about desired changes." R. M. P.

KEEPING UP WITH CHEMISTRY

Thirty-Sixth Annual Report of the Committee on Atomic Weights. Determinations Published during 1929. G. P. BAXTER. *J. Am. Chem. Soc.*, **52,** 857–62 (Mar., 1930).—The only change in the table as published in 1929 [J. CHEM. EDUC., **6,** 1351–2 (July-Aug., 1929)] is that of arsenic given last year as 74.96.

AMERICAN CHEMICAL SOCIETY, ATOMIC WEIGHTS, 1930

Element	*Symbol*	*Atomic Number*	*Atomic Weight*	*Element*	*Symbol*	*Atomic Number*	*Atomic Weight*
Aluminum	Al	13	26.97	Holmium	Ho	67	163.5
Antimony	Sb	51	121.77	Hydrogen	H	1	1.0078
Argon	A	18	39.94	Indium	In	49	114.8
Arsenic	As	33	74.93	Iodine	I	53	126.932
Barium	Ba	56	137.36	Iridium	Ir	77	193.1
Beryllium	Be	4	9.02	Iron	Fe	26	55.84
Bismuth	Bi	83	209.00	Krypton	Kr	36	82.9
Boron	B	5	10.82	Lanthanum	La	57	138.90
Bromine	Br	35	79.916	Lead	Pb	82	207.22
Cadmium	Cd	48	112.41	Lithium	Li	3	6.940
Calcium	Ca	20	40.07	Lutecium	Lu	71	175.0
Carbon	C	6	12.00	Magnesium	Mg	12	24.32
Cerium	Ce	58	140.13	Manganese	Mn	25	54.93
Cesium	Cs	55	132.81	Mercury	Hg	80	200.61
Chlorine	Cl	17	35.457	Molybdenum	Mo	42	96.0
Chromium	Cr	24	52.01	Neodymium	Nd	60	144.27
Cobalt	Co	27	58.94	Neon	Ne	10	20.183
Columbium	Cb	41	93.1	Nickel	Ni	28	58.69
Copper	Cu	29	63.57	Nitrogen	N	7	14.008
Dysprosium	Dy	66	162.46	Osmium	Os	76	190.8
Erbium	Er	68	167.64	Oxygen	O	8	16.0000
Europium	Eu	63	152.0	Palladium	Pd	46	106.7
Fluorine	F	9	19.00	Phosphorus	P	15	31.02
Gadolinium	Gd	64	157.26	Platinum	Pt	78	195.23
Gallium	Ga	31	69.72	Potassium	K	19	39.10
Germanium	Ge	32	72.60	Praseodymium	Pr	59	140.92
Gold	Au	79	197.2	Radium	Ra	88	225.97
Hafnium	Hf	72	178.6	Radon	Rn	86	222.0
Helium	He	2	4.002	Rhenium	Re	75	188.7

Element	Symbol	Atomic Number	Atomic Weight	Element	Symbol	Atomic Number	Atomic Weight
Rhodium	Rh	45	102.91	Thallium	Tl	81	204.39
Rubidium	Rb	37	85.44	Thorium	Th	90	232.12
Ruthenium	Ru	44	101.7	Thulium	Tm	69	169.4
Samarium	Sm	62	150.43	Tin	Sn	50	118.70
Scandium	Sc	21	45.10	Titanium	Ti	22	47.90
Selenium	Se	34	79.2	Tungsten	W	74	184.0
Silicon	Si	14	28.06	Uranium	U	92	238.14
Silver	Ag	47	107.880	Vanadium	V	23	50.96
Sodium	Na	11	22.997	Xenon	Xe	54	130.2
Strontium	Sr	38	87.63	Ytterbium	Yb	70	173.6
Sulfur	S	16	32.06	Yttrium	Y	39	88.92
Tantalum	Ta	73	181.5	Zinc	Zn	30	65.38
Tellurium	Te	52	127.5	Zirconium	Zr	40	91.22
Terbium	Tb	65	159.2				

The Table published by the German Atomic Weight Commission [(*Chem.-Ztg.*, **54,** 52 (Jan. 15, 1930)] differs from the American Table in the following values:

Antimony	121.76	Osmium	190.9
Arsenic	74.96	Potassium	39.104
Columbium	93.5	Rhodium	102.9
Gadolinium	157.3	Rubidium	85.45
Iodine	126.93	Vanadium	50.95
Lead	207.21	Ytterbium	173.5
Neon	20.18	Yttrium	88.93

The German Table gives Lutecium as Cassiopeium (Cp), and Columbium as Niobium (Nb). [See J. CHEM. EDUC., **7,** 1194 (May, 1930)]. H. H. K.

Recent Developments in the American Chemical Industry. R. T. BALDWIN. *Chem. & Ind.*, **49,** 51T–54T (Jan. 24, 1930); 69T–70T (Jan. 31, 1930); 81T–82T (Feb. 7, 1930).—"To the so-called Anglo-Saxon consciousness science has had to date three stages: (1) an elegant philosophy known to a few, (2) a grubby affair with test tubes and ill-smelling substances; and (3) a mysterious enterprise capable of yielding dividends and providing newer, bigger, and better motor cars or airplanes. The chemist himself is yet unplaced in the scheme of things because he is still, in his outlook, in the first stage, and the world and his employer are confused in the second and third stages."

"Acetone is now being made on a very large scale from isopropyl alcohol, which is, in turn, derived from propylene from natural or cracked petroleum gas."

Synthetic ammonia is a very live economic issue as a refrigerant, fertilizer, and perhaps as a cleansing agent.

Other relatively new and important materials are solid carbon dioxide, aniline oil, cellulose products, diphenyl, dyestuffs, fertilizers, solvents, synthetic resins, etc. E. R. W.

Recent Developments in Industrial Organic Chemistry. C. F. H. ALLEN. *Can. Chem. Met.*, **14,** 102–3 (Apr., 1930).—During the last decade the production of large quantities of hitherto rare organic chemicals has become a profitable industry in the United States. In addition new uses have been found for previously known waste or by-products, in some cases making them a main product. The three pentanes are separated, chlorinated to the mono-stage from which the amyl alcohols are derived. Methyl alcohol is now derived from carbon monoxide and hydrogen, and synthetic ethyl alcohol is produced on a semi-commercial basis. As a by-product of "cracked gasoline" industry, unsaturated hydrocarbons in large quantity are formed, from which many of the secondary alcohols are produced. Aldehydes are produced commercially by a catalytic process. A very recent process by one firm is the production of cyanhydrins of aldehydes and ketones by the addition of hydrocyanic acid, and the subsequent hydrolysis of the product in the presence of alcohol, which in turn produces two new solvents, ethyl lactate and ethyl oxybutrate. By a slight modification of the process, lactic acid may be produced which in the future may become a serious competitor of lactic acid production by fermentation. The oxidization of aromatic compounds with air in the presence of vanadium oxide as a catalyst has paved the way for the production of various compounds on a cheaper basis. R. L. H.

Spontaneous Combustion Is Subject of Research. ANON. *Sci. Educ.*, **14**, 561 (Mar., 1930).—At Beltsville, Md., the United States Department of Agriculture is experimenting with stored alfalfa hay in order to study spontaneous combustion in farm products, about which very little is known scientifically. "It is generally believed," says Dr. Skinner, "that the initial heating is caused by the action of microörganisms. The bacteria are eventually killed by the heat which they produce, at a maximum temperature somewhere in the neighborhood of 160°F. It is thought that the subsequent higher temperatures developed in the hay are the results of chemical reactions."

J. H. G.

The Application of Oxygen and Hydrogen to Industrial Operations. F. P. WILSON, JR. **I. The Economics of Hydrogen Procurement.** *Gen. Elect. Rev.*, **33**, 199–202 (Mar., 1930); **II. Electrolene.** *Ibid.*, **33**, 222 (Apr., 1930).—**I.** The industrial uses of gases are becoming more varied. Those interested in the production and use of these gases find a study of the economics of the process to be desirable. In the production of hydrogen one must consider the use for which the gas is intended, the purity limitations, the type of plant necessary for its production, and the various costs attendant thereto.

The two methods of hydrogen production are the by-product, and the non-by-product processes. Combinations of circumstances may dictate which method shall be used. The by-product group includes: (1) electrolysis of water, which is favored if pure hydrogen is necessary, if there are uses for the by-products, if cheap power is available, and if the gas load is large enough to justify the capital investment; (2) the iron contact process which may be profitably operated only when large, steady volumes of gas are needed; (3) liquefaction of water gas which also necessitates a large output of gas to operate successfully; (4) steam and water gas using catalysts, which is a process that is not used to any extent in this country. The non-by-product group includes: (1) dissociation of ammonia which produces a gas suitable for many operations, requires a small capital investment, and is a simple process; (2) cracking of oil, natural gas, or other hydrocarbons (this process is discussed below); (3) cracking of city gas.

II. Electrolene is an industrial gas which very nearly fulfils ideal conditions for many operations. It is made from a hydrocarbon, usually one of butane, propane, ethane, or city gas, in which the chief constituent is methane. The process for its manufacture involves the dissociation of the hydrocarbon at high temperatures, by means of which the gas produced may be made to fit any particular temperature used in an industrial operation. The process is nearly automatic, requires the minimum of capital investment and floor space, and is safe.

H. T. B.

Cultivation and Preparation of Rubber in the United States. D. SPENCE. *Ind. Eng. Chem.*, **22**, 384–7 (Apr., 1930).—The estimated rubber consumption in the United States for this year is 485,000 tons, practically all coming from the *Hevea brasiliensis* growing under intensive cultivation in the Far East. In Mexico a shrub known as guayule has been the source of rubber on a commercial scale for the past twenty years. In 1913 some of this seed was sown at San Diego, and from about 1000 strains produced, those appearing best suited to climatic conditions, ease of propagation, and rubber content were selected, so that now about 5000 acres of these plants are coming into bearing. In 1927 automobile tires were made from guayule rubber grown in California. These ran over 10,000 miles, indicating that with further improvements in the process, it should prove quite satisfactory.

The rubber content in different strains varies from a few per cent to 14 or 16. There is a progressive increase in percentage and total amount of rubber per plant with each year of growth. Plants grown from seed sown less than a year ago contain 6.3% pure caoutchouc on a bone-dry, deleafed basis. On this basis, the yield per acre would be 1164 lb. per year. This compares favorably with results of bud-grafted stock of *Hevea brasiliensis* after 7 years of waiting. The seedlings are gathered and transplanted by a mechanical planter, planting 150,000 in 8 hours. The optimum period of growth before harvesting is 4 years. The plants are pulled and chopped mechanically, dried, and ground. It is washed free from water solubles and fed into a second mill containing small rubber-covered lead balls. Fresh water is added, the shrub is still further disintegrated, but the rubber is caused to agglomerate into small particles about the size of a pea. They are known as "worms" and are then mechanically separated from the fiber by flotation. It is further cleaned and blocked for shipment. All except 0.25% of the total rubber content of the shrub is recovered.

The guayule rubber has the same chemical composition as that from *Hevea*. It is a hydrocarbon, with the empirical formula C_5H_8, and gives the same bromine and chromyl chloride derivatives. It appears to differ somewhat in physical properties, but it is

believed that by a modification in treatment it will resemble plantation rubber more closely. By a process of retting, whereby the shrub is exposed for a week to the action of microörganisms and air, it can be made to resemble plantation rubber quite closely. Indications are that guayule rubber will be produced at a cost, enabling it to compete with plantation rubber. D. C. L.

Indigo. K. MACKENZIE. *Dyestuffs*, **31**, 33–8 (Mar., 1930).—History and methods of dyeing with natural and synthetic indigo are given. A. E. C.

Chemistry and Chemotherapy of Iodine and Its Derivatives. G. M. DYSON. *Chem. Age*, **22**, 362–4 (Apr. 19, 1930); 390–1 (Apr. 26, 1930); 416–7 (May 3, 1930).—The first and second parts of this paper deal with the occurrence of iodine and the methods of obtaining it in pure form from kelp and from the Chilean nitrate deposits. The third part is concerned with the preparation and uses of the compounds of iodine important in medicine. A detailed survey of the synthesis of thyroxin is given. E. R. W.

The Chemical Action of Light. ANON. *Chem. & Ind.*, **49**, 139–40 (Feb. 14, 1930).—A review of a lecture by Max Bodenstein. [See J. CHEM. EDUC., **7**, 518–29 (Mar., 1930)].—Photographic processes and plant growth represent two widely different classes of photochemical phenomena. These processes and the phenomena of vision are discussed from the viewpoint of the absorption of the quanta of light energy necessary for the reaction. E. R. W.

Sterilization with Chlorine and Some of the Newer Industrial Uses. *Can. Chem. Met.*, **14**, 108 (Apr., 1930).—A brief history is given of the manufacture and uses of chlorine. The uses of chlorine as disinfectant, bleach, deodorant, purification of oils, and for the manufacture of new chemicals are described. R. L. H.

Biochemistry and the Problems of Organic Evolution. R. A. GORTNER. *Sci. Mo.*, **30**, 416–26 (May, 1930).—The basic chemical reaction which makes possible life as we know it today may be written as follows:

$$6CO_2 + 6H_2O + 677.2 \text{ Cal.} = C_6H_{12}O_6 + 6O_2$$
(Photosynthesis)

However, certain lower forms of living organisms (bacteria) do not utilize carbon compounds as a source of energy. It is suggested that their energy relationship may be relics of an earlier day when there were no carbon compounds. Reactions of this type include the oxidation of $Fe(HCO_3)_2$ to Fe_2O_3, of H_2S and S to H_2SO_4, and of NH_3 to HNO_3. From the forms of life utilizing these reactions, the author traces the evolution through the development of both plant and animal life, showing the dependence of the animal kingdom upon the plant kingdom and the relationships existing between different members of the former. Organic evolution is given as an explanation of the marvelous harmony prevading throughout the biochemical processes which characterize vital phenomena. G. W. S.

Fertilizer Production. B. L. EMSLIE. *Can. Chem. Met.*, **14**, 98–101 (Apr., 1930).—Fertilizer in the form of manure has been used since primitive times, but the development of commercial fertilizer has been experienced within the past hundred years. Bone meal was the first substitute for manure. In the year of 1840 Peruvian guano, a nitro-phosphatic fertilizer consisting of the decayed remains and excreta of fowls, was introduced into Britain. In 1860 Justus von Liebig announced his discovery of the fertilizer value of potash, and the following year a commercial potash industry came into being. Sulfate of ammonia was added to the list of artificial fertilizers in 1875, and in the year of 1878 a process was perfected for the extraction of phosphoric acid from iron in the manufacture of steel. In 1888 phosphate rock was discovered in Florida, and in Tennessee in 1894. A description is given of the development of fertilizers from synthetic nitrogen. These fertilizers are produced as sodium nitrate, ammonium sulfate, nitro chalk (calcium nitrate and calcium carbonate), and ammonium phosphate. The various fertilizer brands are described. R. L. H.

The Metals in Our Foods. W. H. EDDY. *Good Housekeeping*, **89**, 96 (Oct., 1929).—The quest for food is a powerful factor in motivating human behavior. It is natural that man should study his food. He has always been interested in quantity and taste; for the measurement of the former he turned to the calorie content. Then it was learned that some substances present in extremely minute amounts greatly affected health and utilization of foods. Thus his interest in vitamins was aroused.

Now man is finding that metals are also present in food and serve an important purpose. Blood owes some of its powers to iron, but it seems that inorganic iron salts are of little value, as well as the "organic" iron of which tonic venders boast. Copper and manganese seem to aid the body to utilize iron. Aluminum has been found to be

one agent responsible for bettering reproduction. Cobalt and nickel are suspected of influencing the behavior of certain digestive organs.

The study of the metals present in our foods is only well started. The answers to the following three questions are as yet unavailable: "(1) How much per day of the metals do we need for normal health? (2) If we exceed the normal health quota what does the body do with the excess? (3) Is there a minimum for each metal above which it is dangerous to go, or do the form in which the metal is swallowed and the presence or absence of other conditioning factors so alter its behavior in the body as to make prescription of both safe and dangerous limits impossible?"

The metals occur in minute quantities—a large amount would constitute a menace when taken into the body. One should not lose sight of the fact that most foods contain aluminum. It is obvious, then, that one's choice of baking powder may be a factor in pushing him over a safe limit. H. T. B.

Rhenium Metal and Its Compounds. ANON. *Chem. Age, Mo. Met. Sec.*, **22**, 22–3 (Apr. 5, 1930).—Out of 1600 minerals from all parts of the world about 100 have been found to contain rhenium. No mineral has been found to contain more than 0.001% of the element. Several hundred grams of the metal, in elementary form or in compounds, are now available. Methods of separating the element from the ores, and some properties of it and its compounds are given. They seem to resemble somewhat the properties of manganese and its compounds. E. R. W.

Chromium Plating. E. J. DOBBS. *Chem. & Ind.*, **49**, 161T–165T (Mar. 28, 1930).—A review of the modern practice for chromium plating, including a discussion of solutions and electrodes, preparation of surface to be plated; current density and voltage. Some of the difficulties in forming a good plate are mentioned. E. R. W.

Borax Ore Preparation in Death Valley—A Reminiscence. H. L. GLAZE. *Chem. & Met. Eng.*, **37**, 296–8 (May, 1930).—A description is given of the methods used in processing the borax ores in the production of borax by the dry process. R. L. H.

Titanium Oxide Pigments. N. HEATON. *Chem. & Ind.*, **49**, 143T–150T (Mar. 14, 1930).—Only recently has titanium come to be of industrial importance and as a result it has erroneously been looked upon as a "rare" element. Many industries are now making use of compounds of this element and among the more important is the paint industry. Titanium oxide is a valuable white pigment of great covering power and opacity. It does not react with alkalies or sulfur compounds forming colored compounds. It does not seem to be poisonous or harmful, a point of importance in the preparing of paints. Methods of obtaining the oxide and of using it are discussed. E. R. W.

Economic and Industrial Prospects of Xylose. W. E. EMLEY. *Chem. & Met. Eng.*, **37**, 283–5 (May, 1930).—Xylose is the first five-carbon sugar to be manufactured on a semi-commercial scale. The possibility of this sugar being produced at a cost within range of industrial application depends upon the method of production, present costs, and prospective market. Xylan, on simple hydrolysis, takes up a molecule of water and forms xylose, a five-carbon sugar analogous to dextrose. Xylan occurs in many industrial wastes such as corn cobs, cornstalks, peanut shells, and cottonseed hulls. Cottonseed hulls contain 40% by weight of xylan, and corn cobs and peanut shells are next highest. Approximately 2,000,000 tons of cottonseed hulls are available each year, which represents 800,000 tons of xylan. Hydrolysis of xylan can be carried out on a commercial scale by boiling the xylan-containing material with dilute sulfuric acid, preferably under pressure. The extraction of the xylose thus formed from the gums, ash, and protein constituents is a very difficult procedure. The protein constituent seems to form a protective colloid which prevents the crystallization of xylose. With generous allowances for capital charges it is estimated that xylose will be produced at approximately 25¢ per pound. If the market is large it may be produced at 15¢ per pound. Utilization of xylose as food sugar would afford the largest prospective market. Xylose perhaps has a future use by diabetics, providing the human system can tolerate these five-carbon sugars. By mild oxidization of xylose, tri-oxy-glutaric acid is formed, which in many respects resembles citric acid, and is apparently suitable for use in foods, beverages, and flavoring. It also has found industrial application in tanning and dyeing. Interesting possibilities are offered for xylose in the field of explosives, plastics, lacquers, and the like. Illustrations are given showing the plant process for the production of xylose from cottonseed hulls. R. L. H.

Producing Naval Stores from Waste Wood. R. C. PALMER. *Chem. & Met. Eng.*, **37**, 289–92 (May, 1930).—A brief description is given of the production of turpentine, pine oil, and rosin from waste wood. The preparation of the wood for process-

ing, extraction of turpentine, pine oil, and rosin from the pulp, and the separation of the constituents are also described. R. L. H.

The Chemistry of Cellulose with Special Reference to Rayon. A. W. SCHORGER. *Chem. & Ind.*, **49**, 154T–159T (Mar. 21, 1930).—Cellulose is a typical colloid but its colloidal properties are modified to a large extent by various chemical actions. The study of these actions is handicapped by the fact that the constitution of cellulose is not known. The author points out the correlation between the various formulas which have been advanced for cellulose and its known properties. Until the constitution is determined it will be impossible to form solutions of cellulose and its derivatives and to convert them into sheets and filaments in a rational manner. Thirty or more references are included. E. R. W.

The Micelle Chemistry of Cellulose. C. J. J. FOX. *Chem. & Ind.*, **49**, 83T–88T (Feb. 14, 1930).—Classical chemistry has given some insight into the structure of cellulose, although no solution of it is known and its molecular weight is still a mystery. X-ray studies have given some indication as to the structure of the cellulose micelle. This probably consists of from 1500 to 2000 glucose residues, arranged in from 40 to 60 cellobiose chains, each containing 30 to 50 glucose residues. Some of the different processes for the manufacture of artificial silk are interpreted on the basis of this structure. A short bibliography is included. E. R. W.

Films and Fibers Derived from Cellulose. H. LEVINSTEIN. *Chem. & Ind.*, **49**, 55T–57T (Jan. 31, 1930); 78T–80T (Feb. 7, 1930).—A brief review of the theories of the structure of cellulose, and of the economic importance of the different cellulose derivatives, especially the nitrate and acetate. E. R. W.

Freezing Cracked Ice by the Ton. ANON. *Inco*, **9**, 12 (1930).—Cracked ice may now be frozen continuously by a machine which produces it at the rate of ten tons per day. This machine can be made to freeze other liquids and its design permits an increase in capacity to forty or more tons per twenty-four hours.

The cracking is accomplished by freezing the ice in a layer upon a metal surface by absorption of heat through the metal. Then an automatically controlled series of levers causes the ice to peel off by changing the shape of the surface.

The size of the ice flakes can be regulated to a surprising degree. The usual dimensions are one-inch square and three-sixteenths of an inch thick. The thickness of the ice flake is very easily varied by altering the "set" of different parts of the machine's mechanism.

The production rate is determined by the temperature of the water to be frozen, of the temperature of the absorbing brine, the velocity of the brine through the machine, the speed of rotation of the freezing cylinder, the amount of the cylinder's deflection and the time between deflections. B. C. H.

Factors in the Use of Pulverized Fuel. J. T. DUNN AND B. MOORE. *Chem. Age*, **22**, 322–3 (Apr. 5, 1930).—This article treats of the theory and mechanism of combustion, methods of pulverizing fuel, and the advantages of pulverized fuel. Chief among the advantages are; ease of regulation and control, rapid alteration in rate of burning, labor saving, cleanliness, and possible use of inferior fuels. E. R. W.

The Insulation of Heated and Cooled Surfaces. J. S. F. GARD AND R. S. ROBINSON. *Chem. & Ind.*, **49**, 125T–138T (Mar. 7, 1930).—A comprehensive review of the problems of insulation. E. R. W.

The Action of Potassium Permanganate on Unsaturated Hydrocarbons. D. A. HOWES AND A. W. NASH. *Chem. & Ind.*, **49**, 113T–119T (Feb. 28, 1930).—Description of experiments carried out in an attempt to determine unsaturated hydrocarbons in motor fuel by means of potassium permanganate. The lower unsaturateds were found to be easily oxidized but the higher unsaturateds of branched chain structure are difficult to oxidize. These higher unsaturateds seem to have greater effect than those of lower molecular weight in preventing knocking. E. R. W.

Wetting, Spreading, and Emulsifying Agents for Use with Spray Fluids. I. Wetters and Spreaders, II. Emulsifiers. *Chem. & Ind.*, **49**, 93T–98T (Feb. 14, 1930); 193T–197T (Apr. 18, 1930).—Spray materials should wet and spread over fungi they are designed to kill, or over trees they are to protect from insects. In order to promote this wetting and spreading the surface tension of the spray material should be lowered. Sodium and potassium soaps are commonly used for this purpose although they have obvious disadvantages. Barium caseinate may serve both as a wetter and as a poison. The soaps are sometimes used as emulsifying agents, although their tendency to form calcium and magnesium soaps in hard water does not favor the formation of the stable oil in water emulsions which are best for spraying purposes. Several tables are given in which various agents for wetting or emulsifying are compared. E. R. W.

Catching Up with Chemistry. See this title on page 1961.
Opportunities in Science. See this title on page 1961.
Historical Outline of the Adoption of the Metric System. See this title on page 1956.
The Practical Difficulties of Introducing the International Metric System into the United States. See this title on page 1960.
Statistical Data 1928 for Chemical Instruction. See this title on page 1944.

SCIENTIFIC REVIEWS AND BIBLIOGRAPHIES

Contemporary Views on the Nature of Electrolytes. N. BJERRUM. *Ber.*, **62**, 1091–103 (1929).—I. In 1908, Hantzsch and Bjerrum showed experimentally that the color of electrolytes was independent of the concentration over a wide range. Hantzsch concluded that ionization was without influence on the color; Bjerrum concluded that the electrolytes were completely dissociated. The latter theory has since proved very fruitful, but owing to the neglect of the ionic charges, the complete dissociation of many electrolytes was not observed in the first decennium of the electrolytic dissociation theory.

In computing the effect of the ionic charges, it is first necessary to consider the inter-ionic forces, secondly, the forces between the ions and the solvent, and, thirdly, the dimensions and deformability of the ions.

II. At 100,000°, the thermal translational forces are so great that the ions practically move independently of one another, but at 2000° the inter-ionic forces are the larger, and the vapor of an electrolyte, such as NaCl, is composed mainly of molecules which have no electrical conductivity. At lower temperatures the inter-ionic forces cause a further association to one large ionic aggregate in the liquid phase, but the ions retain their mutual freedom of movement. This is shown by the approximately equal molar conductivity of fused salts and solutions. When the temperature is further lowered so that solids are formed, the inter-ionic forces are so strong that the ions are held rigidly in the crystal lattice. By calculating the energy necessary to tear the lattice apart and subtracting the energy recovered by the recombination of the ions to form single vapor molecules, the values are found to be in substantial agreement with the heats of evaporation. Similarly, the hardness of crystals, their lattice structure, and their ease of melting are readily explained by assuming the independent existence of deformable ions.

III. In water solutions, the inter-ionic forces are reduced to $^1/_{80}$ of their magnitude in the gaseous state, because the dielectric constant of water is 80. The forces are by no means negligible, however, and Debye and Hückel have shown how they account for changes in osmotic pressures, electrical conductivities, and activity coefficients as solutions are diluted. Heats of dilution at first caused some difficulty when it was supposed that they ought to be negative, but Debye has shown that positive heats of dilution may also be expected because water is a dipole, the potential energy of which is converted to heat when the field strength is decreased as the ions are moved farther apart.

For solutions more concentrated than 0.01 *N*, the Debye-Hückel theory is not wholly satisfactory, partly because the dielectric constant of water is not accurately known and partly because the phenomena in the immediate vicinity of the ions play such an important rôle in concentrated solutions.

In solvents of low dielectric constant, the inter-ionic forces are greater and the deviations from the ideal results expected from the theory of complete dissociation appear at even lower concentrations than in water. One anomaly is common to all such solvents: the molar conductivity passes through a minimum in going from dilute to concentrated solutions. The smaller the dielectric constant, the more dilute are the solutions in which this minimum appears. The explanation of this phenomenon is that near the minimum the inter-ionic forces tend to pull the ions together as molecules. As the concentration decreases, these forces decrease and the molecules dissociate; as the concentration increases, the ions approach their condition in a fused salt where the conductivity is good.

IV. One of the most important functions of the new theory is the explanation of solubility relations. Solubility is closely related to heats of solution, and according to Fajans, these may be regarded as the difference between the heat of hydration of the ions and the lattice energy of the solid salt. The work required to carry a charged sphere of given radius from a vacuum into a dielectric medium is partly dependent on the radius, and if this work is assumed to be identical with the heat of solution, we have

data for the calculation of ionic radii. The agreement with crystal measurements is satisfactory.

By taking into account the charges on the ions, the radius of the ions, and the difference in the dielectric constants of two solvents, it is possible to calculate the relative solubilities of a salt in the two solvents. A general conclusion from this calculation is that water should be a good solvent for most salts, and that salts with multivalent ions should be much less soluble in alcohol than in water.

A further conclusion of interest is that salts with ions of equal volume should be relatively insoluble.

V. With respect to weak electrolytes, Bjerrum believes that it will be most profitable to consider them as only partially dissociated, and make use of the degree of dissociation as well as purely physical coefficients in deriving quantitative expressions for their behavior. In very concentrated solutions, difficulties are also encountered in explaining light refraction and absorption. The present-day successes of physics in fields which formerly belonged to chemistry might lead to the thought that the application of chemical principles was only a mark of physical incompleteness. The more clever the physicist, the less is there left for the chemist to do. Bjerrum, however, feels that the matter is not quite so simple, because of the numerous instances in which there is a sharp distinction between ions and molecules, or rather between conducting and non-conducting states of matter. H. C. D.

The Scope and Problems of Modern Physics. V. KARAPETOFF. *Gen. Elec. Rev.*, **33**, 306 (May, 1930).—By modern physics is meant that portion of the science dealing with atoms, electrons, quanta, and radiation. Young engineers should attempt to get a bird's eye view of the subject before they settle down to one limited field because of the overlapping of fields. Under the topic of electrons, an investigator may be interested in the electric charge on an electron, the deflection of an electron under electromagnetic or electrostatic fields, glow discharges, sparkovers, etc. Lists of topics are given under each of the general heads above. The author has also included an alphabetical list of topics, and a list of references. H. T. B.

Some Relations between Physico-Chemical and Biological Periodic Phenomena. E. S. HEDGES. *Chem. & Ind.*, **49**, 121T–124T (Feb. 28, 1930).—A brief account of some of the analogies between periodic muscular contraction such as heart-beat and periodic chemical actions such as the passivity of iron, decomposition of hydrogen peroxide by mercury, dissolution of metals, electrode phenomena, etc. E. R. W.

Possible Sources of Error on pH Determinations. See this title on page 1943.

Chemistry and Chemotherapy of Iodine and Its Derivatives. See this title on page 1949.

HISTORICAL AND BIOGRAPHICAL

Alfred Werner. (1) P. PFEIFFER. J. CHEM. EDUC., **5**, 1090–8 (Sept., 1928).—Biographical and historical; (2) G. T. MORGAN. *J. Chem. Soc.*, **117**, 1639–48 (1920).—Obituary notice; (3) P. KARRER. *Helv. Chim. Acta*, **3**, 196–232 (1920).—Biographical material, portrait, and complete bibliography of Werner's publications. M. W. G.

Henry E. Armstrong. See item on **The Albert Medal** on page 1973.

Niels Bohr. See item on **Royal Society of Edinburgh** on page 1975.

Ludwig Claisen. H. BAUSCH. *Giorn. chim. ind. applicata*, **12**, 106 (Feb., 1930).—Dr. Ludwig Claisen died at Bad Godesberg on the 5th of January, 1930, at the age of 79. Claisen received his doctorate at Monaco in 1887 in organic chemistry and taught at Aachen, Kiel, and Berlin. He retired in 1907 from teaching on account of his health and devoted himself to scientific research exclusively in his own laboratory. Among his numerous and important publications are "Condensation of Esters," works on the transposition of non-saturated phenol ethers, and studies on compounds of importance to the problem of tautomerism. M. A. C.

Karl Johann Freudenberg. See item on **University of Wisconsin,** page 1973.

The 70th Birthday of Prof. Dr. E. Gildemeister. WIENHAUS. *Z. angew. Chem.*, **43**, 301–2 (Apr. 12, 1930).—On April 16th, Edward Gildemeister was 70 years old. Since 1894 he has been one of the most active members of the Verein Deutscher Chemiker. He is well liked and admired by his colleagues.

He was born in Bonn and studied pharmacy in Munich and Freiburg. His first research work at the university was in the field of terpene and camphor. He received his degree on June 30, 1888, from the University of Freiburg. In the fall of the same year he obtained a position with Schimmel & Co. in Leipzig where he performed a large amount of excellent research work on ethereal oils. He worked out a volumetric method of determining phenol and determined the physical constants of many oils. In 1892

he came to the United States and founded a branch at Garfield, N. Y. In 1900 he became director of the chemical laboratory and in 1917 president of the company. L. S.

James C. Irvine. See item on **St. Andrew's University, Scotland,** on page 1976.

Nicola Parravano. See item on **University of Rome, Italy,** on page 1975.

Elbert W. Rockwood. See item on **University of Iowa,** page 1971.

Alexander Silverman. See item on **University of Pittsburgh,** page 1972.

Friedrich Stolz. BOCKMÜHL. *Z. angew. Chem.*, **43**, 285–6 (Apr. 5, 1930).—On April 6th, Friedrich Stolz celebrated his 70th birthday. Forty years of his successful life he devoted to industry. He was born on April 6, 1860 in Heilbronn. He studied pharmacy at the University of Munich. He and many others were attracted to Munich by A. v. Baeyer. He worked under v. Baeyer for his doctor's thesis (iodinepropargyl acid). In April, 1890, Stolz accepted a position at the Farbwerke Höchstein. Vongerichten who at that time was head of the scientific laboratory recognized Stolz's ability and gave him the problem of working on the development of the chemistry of antipyrin.

Stolz soon made some valuable contributions which were announced in a number of articles and patents. He discovered pyramidon which is still considered a valuable preparation. His greatest success is the proof of the structure and the synthesis of adrenalin. It was the first time that a hormone could be prepared successfully in the laboratory. L. S.

The 70th Birthday of Prof. Dr. J. Traube. L. J. WEBER. *Z. angew. Chem.*, **43**, 261–74 (Mar. 29, 1930).—On March 31st, Dr. Traube celebrated his 70th birthday. In spite of his age he is full of life and vigor. The value of his works is now first being appreciated. He was born in Hildesheim. When he was a young man he became interested in natural sciences. He studied chemistry in Berlin and his doctor's thesis was: "The Action of Cyanogen Chloride on Amido Acids." After having been assistant in Heidelberg and Bonn he went to Hannover where he and Bodländer directed a chemical laboratory for several years. In 1891 he became a member of the staff at the Technische Hochschule in Berlin. In 1898 he was made *dozent* and in 1900 professor of physical chemistry. At the same time he was directing his colloid chemical laboratory.

Traube was one of the first men to occupy himself with capillary-chemical problems. He studied the effect of a large number of organic substances on the surface tension of water and proved that the properties of a solvent are greatly changed by the solutes dissolved in it. He worked on van der Waals' equation of state and the solubility of so-called insoluble substances. He found by means of the Tyndall effect that anisotropic colloid particles can be detected not only with the ultramicroscope but also macroscopically by the rotatory components of their Brownian movement. He studied flotation, foam systems, adsorption, protective colloids, and many pharmacological and industrial problems. Among the latter should be mentioned his work on alcohol, gypsum, glass, sedimentation, latex, sugar, and tobacco.

He has published many articles in physical, chemical, biological, and industrial journals of Germany and other countries and he is the author of an excellent textbook of physical chemistry. His book "Physikalisch-Chemische Methoden" has been translated into English. He is the founder of the *Internationales Journal für Physikalisch-Chemische Biologie*. L. S.

Faraday Centenary Celebrations. See page 1974.

Pasteur House. See **La société des amis de la maison natale de Pasteur** on page 1975.

Some 1930 Anniversaries. G. TESTI. *Giorn. chim. ind. applicata*, **12**, 103 (Feb., 1930).—**1630**—Birth of John Kunkel, professor of chemistry in the University of Wittenberg and court chemist. He was called from Berlin, where he was directing glassworks, to Sweden by Charles XI and given the title of baron. He died at Stockholm in 1702. Noted for his long and courageous fight against the theories of the alchemists, still in force, he introduced into chemical research an experimental rigorism which led him to important applications. His principal publication is the "Laboratorium Chymicum," in which he described how he found out the secret of the manufacture of phosphorus by Brand. He discovered the secret of the manufacture of glass by chance, studied fermentation and putrefaction, separation of gold, essential oils; discovered nitrous ether and some organic substances.

1630—Jean Rey, French chemist and physician, demonstrated experimentally that air has weight and that it combines with some metals during calcination. This

great discovery was derided and then neglected by scientists but it was afterward adopted by Mayow and a century and a half later by Lavoisier.

1730—The birth of Felice Fontana at Rovereto. He was the founder of gasometry and the inventor of a kind of eudiometer for measuring gases. To this great Italian chemist belongs the discovery of water gas, of the absorbing property of carbon, of the constancy of weight in chemical reactions, and an imposing number of experimental studies which place him among the greatest chemists of his time. A great friend of Priestley, he believed, like him, in the theory of phlogiston; he was director of the famous Museum of Physics and Natural History of Florence. He suffered political persecution for his liberal ideas. He died in 1805 and was buried in Santa Croce near Galileo and Viviani.

1830—Carlo Matteucci (1811–68), famous physicist of Forlì, professor in the University of Pisa and afterward Minister of Public Instruction, showed, before Faraday, that a constant quantity of electricity is necessary to liberate an equal quantity of binary compounds of the formula A. R. and proved that the quantity of electrolyte deposited is proportional to its atomic weight divided by its valence. He was celebrated for his studies on the decomposition of metallic salts, of acetic acid and other vegetable acids; he was the first to apply electrochemistry to physiology.

1830—Thomas Graham discovered at Glasgow that gases move and are diffused with a velocity inversely proportional to the square root of their density.

1830—Vanadium was discovered by Sefström of Sweden.

1830—The birth of Francis Raoult, professor at Grenoble, noted for his classic work on cryoscopy, on the tensions of steam, thermochemistry, and electrochemistry. He died in 1901. M. A. C.

A German Sugar-Cane Factory in the 15th Century. *Forschungen Fortschritte* (Dec. 1, 1929); *Giorn. chim. ind. applicata*, **12**, 58 (Jan., 1930).—This describes a sugar-cane factory which an association of German merchants, the Grosse Ravensburger Handelsgesellschaft of southern Germany established in 1460 at Valencia, Spain. This association had commercial relations in many foreign countries and in Aragon. One of its wares was sugar cane.

Since the 8th century sugar cane had spread from northern Africa over the southern coast of Spain to Valencia. The Ravensburger Gesellschaft conceived the idea of establishing a factory in these places near the sugar-cane plantations. Dr. Münzer, a physician of Nuremburg, who made a trip to Valencia some time later, has left in his letters a description of the factory and plantations there. The cane was gathered, cut in small pieces, and pressed in large machines turned by mules and horses. The sugary juice was collected, filtered, and cooked over a naked fire to the consistency of sirup and then placed in forms of "loaf-sugar" made of palm leaves. This rough sugar, dissolved, filtered, and concentrated several times again, finally gave pure sugar. The factory came to be universally known as a "sugar refinery." From Valencia the sugar spread to the Rhone, Provence, Savoy, Burgundy and Lyon, then to Geneva, the most important market in southern Europe, and at last to Ravensburg. But after a dozen years difficulties arose on the plantations and the property of the proprietors was confiscated for political reasons; then later came competition with Portuguese sugar from the islands west of Africa. Sugar fell in price and at last in 1480 the factory closed. M. A. C.

Sam Smith's Discovery Has Made Many Millionaires. J. T. FLYNN. *American*, **106**, 64–5 (Apr., 1930).—Sam Smith, an aged resident of Titusville, Pennsylvania, tells, through the author, how the crude oil came up in the salt wells, much to the annoyance of the salt men, before oil wells were known. The first use of the oil was by the Seneca Indians as a sort of liniment. William H. Bissell was responsible for the oil's analysis by Professor Silliman of Yale. He was also organizer of the Seneca Oil Company.

At first the company obtained the oil by soaking it from the surface of the river in blankets. The picture of a salt well derrick upon one of the oil-liniment bottles suggested the possibility of getting oil out of a well. It was Edwin Drake who, when persuaded to give up his job as conductor on the New Haven railroad, went to Pennsylvania and took charge of making the first oil well. Sam Smith's father, a blacksmith of Tarentum, undertook to surmount the mechanical difficulties of the enterprise.

On August 27, 1859, after three months' work, Sam Smith himself saw the first oil come up through the six-inch pipe around the drill. The collection of barrels and containers of all sorts for this rock oil as it was pumped for the first time from a well, the sudden transformation of a village into a city, and the effect of all this upon the simple farmer people of the region make a story of more than passing interest. B. C. H.

The Deutsches Museum, Munich. *Nature* (London), **125,** 638–41 (Apr. 26, 1930).—This is a short description of the Deutsches Museum, whose aim, according to their report, "is to illustrate the development of research and discovery of every age and of all countries. An institution in which the results of scientific research and experiments should be fully known." The Museum in a larger way has three objects: First, the exhibition of models and of collections of original apparatus of famous workers in science. Interiors affording a human touch are a great feature: for instance, a copy of a Swiss watchmaker's shop with its hand tools, side by side with a modern factory with machine tools; reproductions of an alchemist's and of an eighteenth century laboratory; a scriptorian with a monk copying a missal, etc. Second, another outstanding feature is its direct educational purpose. Thus much experimental apparatus is so arranged that the visitor can demonstrate many of the natural laws and reproduce especially some of the more striking results of modern physics. Third, there is the conception of a great library which will contain manuscripts and books on science, portraits, lantern slides, periodicals, drawings, diagrams, films, in fact a complete record so far as possible of the march of science. There are in addition lecture halls which will accommodate from two hundred to two thousand people.

It is very fortunate that Germany and Munich are willing to foster an institution of this kind which will be a permanent record of the advance of science. [See J. CHEM. EDUC., **7,** 762–81 (Apr., 1930).] F. B. D.

Historical Outline of the Adoption of the Metric System. *Ray,* **7,** 20–4 (May, 1930).—In the eighteenth century there existed a great diversity of weights and measures, which everywhere handicapped commerce. It was under this influence that the first steps were taken toward standardizing weights and measures. In May, 1790, a bill in favor of a new system of weights and measures was passed, invoking the French Academy of Science to report on the same. In order to secure an internationally acceptable unit of measure, the committee appointed by the Academy recommended that a decimal fraction of the earth's circumference be used: namely, the ten-millionth part of the meridional distance from the north pole to the equator, through Paris. It was likewise proposed that a system of weights based upon multiples and submultiples of the weight of a cubic meter of water at the melting point of ice should be substituted for the confused system then in use. France issued invitations to allied powers to send scientific delegates to Paris to definitely assign the proper values to the standard meter and kilogram. R. L. H.

History of the Development of Science. See **The New World of Science** on page 1958.

History of the Manufacture and Uses of Chlorine. See **Sterilization with Chlorine and Some of the Newer Industrial Uses** on page 1949.

History of the First Oil Well in the United States. See **Sam Smith's Discovery Has Made Many Millionaires** on page 1955.

Indigo. See this title on page 1949.

EDUCATIONAL MEASUREMENTS AND DATA

The Mathematics of General Inorganic Chemistry. L. L. BOLES AND H. A. WEBB. *Sci. Educ.,* **14,** 539–46 (Mar., 1930).—The question arises as to whether mathematics is needed in the teaching of high-school chemistry and freshman college chemistry. Then again how many teachers leave out part or all of the mathematics. The textbook which omits mathematics altogether is yet to be written. The authors made an analysis of fifteen inorganic chemistry high-school texts and eighteen of college level. Their summarized conclusions are that whatever mathematics is presented in the texts examined, it is concentrated in the first few chapters. The problems are both chemical and physical, use the principle of simple proportion, and usually ask "How much?" Problems are centered about oxygen, hydrogen and chlorine, potassium chlorate, water, and sulfuric acid. There is a striking similarity in the mathematics of both the high-school and college texts. J. H. G.

The Results of the Experiment with Eastman's Classroom Films. T. I. FINIGAN. *Nature Sci. Educ. Rev.,* **2,** 56–63 (Jan., 1930); *cf.* J. CHEM. EDUC., **6,** 153–7 (Jan., 1929).—In an effort to answer the questions: (1) May a series of motion pictures be developed which will be effective teaching agencies? (2) May the contribution of such films to classroom instruction be measured? (3) In the event there is such a measurable contribution, is it sufficient to justify its cost? Arrangements were made in twelve cities to try out films for teaching. Ten units in geography and ten in general science were organized, filmed, and used in a master educational experiment to answer these ques-

tions. Two impartial directors of the experiment were in charge and their summary criticisms of its outcome form a brief part of this report of the method and its results.

In brief, "The results of the experiment show that the work of the film group was distinctly superior to that of the non-film group. The film group gained more (111 per cent more for the general science classes and 117.9 per cent more for the geography classes) than the non-film group in the twelve weeks of instruction."

The teachers in an almost unanimous voice testify: (1) A sustained as well as a heightened interest was engendered by the films. (2) The pupils were stimulated by the films to make models and to engage in other types of self activity. (3) Pupil reading was greatly augmented. (4) Classroom discussion was more animated and sustained in the groups using the films. (5) Improved vocabulary range and accuracy were very noticeable for the pupils who were in the groups using the films. B. C. H.

Predictive Significance of the Correlation Coefficient. C. L. HUFFOKER. *J. Educ. Research*, **21**, 46–8 (Jan., 1930).—A recent writer says: "It is doubtful whether any prognostic test ever has risen consistently above an efficiency of 30 per cent."

The author endeavors to find a probable cause of failure to secure better prediction. He believes that the failure of tests to predict scholastic success may not be due to defects of the tests so much as the unreliability of the criterion, which has been in most cases the teachers' marks. R. M. P.

The Status of Science Teaching in the Secondary Schools of Mississippi. Part II. C. CAIN. *Nature Sci. Educ. Rev.*, **1**, 175–81 (July, 1929). [For abstract of **Part I** see J. CHEM. EDUC., **6**, 2288 (Dec., 1929).]—This paper is a report of a survey begun in 1926. Aspects of the problems considered are: sciences offered, grade placement of the sciences, laboratory layouts, textbooks used, the science teachers, methods of teaching used, and results of science instruction.

From this study chemistry is offered in but twenty-five per cent of the four-year high schools and but four per cent of these schools require it. In explanation the author states, "This small offering is not entirely a matter of cost of laboratory equipment, for its cost is less than that for physics and yet it is offered in fewer schools than physics."

Fifty-five per cent of Mississippi's 353 four-year high schools have their chemistry in the eleventh grade and thirty-eight per cent in the last year of high school. Chemistry has an appreciably better laboratory layout than any of the other sciences.

B. C. H.

An Analysis of Tact. P. M. SYMONDS. *J. Educ. Research*, **21**, 241–54 (Apr., 1930).—The author together with a number of his graduate students collected items which were classified and listed showing habits and thoughtless actions that cause annoyance to others. Under fourteen headings 1173 items were classified. The author concedes that "the completed list should more justly be called an analysis of *tactlessness*."

The success of teachers, salesmen, and others who work with people, depends largely upon acquired habits of social adjustment. A study of this well-organized report of research in this field will give help to any one interested in social conduct.

R. M. P.

Language Requirements for Doctors of Philosophy. G. H. BETTS. *Sch. & Soc.*, **31**, 343–6 (Mar. 8, 1930).—An attempt to determine the value of the foreign language requirement for American Ph.D.'s was made at Northwestern University where inquiries were sent out to 3500 such graduates. All the various fields of study and all the universities in the Am. Assoc. of Universities were represented.

The writer urges, as a possible solution to the language question, a further study along this line by each separate field of scholarship, with a final accumulation of the "fact-studies." K. S. H.

THE PHILOSOPHY OF EDUCATION

Attacking Problems of Intellectual Achievement. *Assoc. Am. Coll. Bull.*, **16**, 234–42 (May, 1930).—That wide-awake colleges are busily attacking this problem is evidenced by the collected statements taken from the association's mail bag. Here one may read what specific schools are doing to establish standards of scholarship and an atmosphere of scholarly ideals; how in the honors college we have a "new way of life in American education, a creative adventure in scholarship"; how in the independent study plan and in the comprehensive examination we have the greatest incentives to intellectual life on the part of faculty and students. The president's program at the University of Chicago is also given, which plan includes the undergraduate colleges, the graduate department, and the professional schools. Among the items of improvement planned by the latter University are: giving better instruction to the undergraduates; (Thornton Wilder, author of "The Bridge of San Luis Rey," is dealing exclusively with undergraduates) dividing the training for Ph.D.'s who are to teach from the training for Ph.D.'s

who are to be research workers; increasing the national character of the student body by scholarships, and by making it clear to prospective students that the University of Chicago has a distinctive and worthwhile undergraduate program. G. O.

A Plea for the Genius. E. B. PLACE. *Sch. & Soc.*, **31,** 288–9 (Mar. 1, 1930).—With vast sums being spent for the education of those of average and inferior intelligence, it is unfortunate that the genius, even though in the minority, should be neglected. Pres. Eliot's system of free electives has of necessity had to reshape itself, but shouldn't there be some such system for the individual who is not interested in degrees—but rather in some of the opportunities which the universities have to offer? K. S. H.

Needed: New Life in the Colleges. C. D. JACKSON. *Sch. & Soc.*, **30,** 415–8 (Sept. 28, 1929).—Though the U. S. has always provided both elementary and secondary education for all, it has failed to recognize the need of advanced education of a selective nature—appropriate to the unusual mind. Certain of the honors groups plans have met this demand to some extent, but there still remain to be opened up paths by means of which those minds needed for leadership may be discovered and developed. K. S. H.

Specialized Education and Its Vices. D. B. KEYES. *Sci. Mo.*, **30,** 538–40 (June, 1930).—A criticism of the modern tendency of students toward specialization in their undergraduate years. Numerous examples are given to show that the young man who has a good fundamental knowledge of science, and who has not been anxious to specialize in any one particular branch, is more easily adaptable to any research investigation and hence advances more rapidly. To become a specialist, one must spend much more time in preparation than is possible for the undergraduate. It was also pointed out that one of the reasons for the larger number of chemists engaged in industrial research is that the student of chemistry is always anxious to acquire all the physics and mathematics he can, and often takes, as elective courses, mechanical or electrical engineering. G. W. S.

Educating the Educators. A. M. PALMER. *Bull. Am. Assoc. Univ. Profs.*, **16,** 296–8 (Apr., 1930). See J. CHEM. EDUC., **7,** 933–4 (Apr., 1930). B. C. H.

The Scientific Method in the Study of Education. See this title on page 1960.

A Background for Research. See this title on page 1960.

The Place of Research in the Undergraduate College. See this title on page 1945.

Why Students Fail. P. L. VOGT. *Sch. & Soc.*, **30,** 847–8 (Dec. 21, 1929).—Failure to adjust oneself to a different environment when placed in college is, in the main, the cause of so many failures. K. S. H.

THE PHILOSOPHY OF SCIENCE

Science and the Money Minded. T. S. HARDING. *Atlantic Mo.*, **145,** 622–31 (May, 1930).—An attempt to show that work contributing to the growth and the enhancement of fundamental knowledge is not an activity which has a high economic value in our civilization. It is quite generally admitted that our present civilization rests upon the brains of the men of science. The scientist, however, must depend for continuing his research upon the interest aroused in laymen who have economic or political minds, *i. e.*, money-minded men. While this means time wasted, a break upon the advance of science and loss to the general public, it is inherent in the fundamental organization of our social and economic system. The popularization of science is a futile and largely impotent gesture so long as the fundamental basis of our social structure naturally gives all direction and power to money minds and practically no power, with scant reward, to the productive brains. Because we educate people to do, not to be, those who dispense knowledge to youth do so under such circumstances that they erect in the student's minds a wall against which the fundamental scientists who discover knowledge have later to thrust themselves in order to get funds for their work. Until this wall is demolished and men are respected for what they are rather than exclusively for what they do, no amount of popularization of science can ever be really successful. The relatively complacent self-satisfaction of the scientist is, in the opinion of Harding, unmerited. The situation exists. If any remedy is needed, it is in the hands of the scientific workers. G. W. S.

Science, the Soul of Prosperity. J. J. CARTY. *Rev. Reviews*, **81,** 60–4 (May, 1930).—An interesting discussion, by the vice-president of the American Telegraph and Telephone Company, of some of the relations of science to the remarkable progress which has been made during the last few years. "The pure scientists are the advance guard of civilization. By their discoveries they furnish the engineer and industrial chemist and other applied scientists the raw materials to be elaborated into manifold agencies for the amelioration of mankind." G. H. W.

The New World of Science. J. A. THOMSON. *Atlantic Mo.*, **145,** 838–50 (June,

1930).—The developments of science are briefly traced from the time when Galileo resolved the Milky Way into a galaxy of separate stars, through important advances in the physical sciences to show that from age to age science has given mankind a new world. The inorganic and organic worlds were brought together by Wöhler in 1828, while the study of plant and animal life shows such similarities in the different forms that they are being brought ever closer together. With these as a background, T. discusses the unity of mind, *i. e.*, the evidence of a mental aspect throughout the whole animal world, which he suggests points to the possibility of men and women rising at their best to a yet higher integration. G. W. S.

The Laboratory—the Key to Progress. C. L. PARSONS. *Chem. Age*, **22**, 384–5 (Apr. 26, 1930). See J. CHEM. EDUC., **7**, 821–7 (Apr., 1930). E. R. W.

Relationship of the New Physics and Physical Chemistry to the Curriculum. A. NOYES, JR. *Rept. New Eng. Assoc. Chem. Teachers*, **31**, 157–67 (May, 1930).—The new theories lack the picturesqueness of the old but they do lead to correct results in cases where the old theory was wrong and have made predictions of great value.

What will this new physics do for chemistry? It would be rash to predict the extent to which the new physics and physical chemistry will affect us but things have gone so far and look so promising that we cannot afford to neglect these fascinating fields. O. C.

PROFESSIONAL

The Dignity of the Professor. *Sch. & Soc.*, **31**, 93 (Jan. 18, 1930).—In the Am. Assoc. of Univ. Profs. college teachers find their only protection against criticism and dismissal for independence of thought and freedom of speech. "When university professors who have served the cause of scholarship for 30 years can be dismissed and disgraced, with less consideration than any street cleaner or farmhand would expect and receive, the name 'university' needs redefinition," says the *Herald-Tribune*. K. S. H.

The Training of Teachers of Science for Junior and Senior High Schools. J. M. SHAVER. *Nature Sci. Educ. Rev.*, **2**, 69–74 (Jan., 1930).—The author considers the curriculum for such teachers in this paper. From a series of eight studies of the job the high-school science teacher will face when he begins teaching, the conclusion is that; "one out of ten will teach a single subject; three will teach two subjects; three, three subjects; two, four subjects; and one, five subjects."

The most common combination for the more than one subject load are one science with another or with mathematics.

It would follow that the training institution for such teachers should give not less than a year in each of the sciences and mathematics to the prospective high-school science teacher. B. C. H.

Ten Questions for High-School Teachers. H. H. HILL. *J. Natl. Educ. Assoc.*, **19**, 143–4 (May, 1930).—The following questions may be used for judging the best high-school teachers. 1. Does the teacher pay attention to the physical conditions of the room? 2. Is good discipline evident without apparent compulsion? 3. Is any method other than the textbook-recitation in evidence? 4. Is there a plan for adaptation to individual differences within the class? 5. Does the teacher use new-type tests and if so, for what purpose? 6. Is there evidence of a lesson plan? 7. Is the teacher interesting or dull? 8. Has any attempt been made to create classroom atmosphere? 9. Is the teacher carrying on what for her is a classroom experiment? 10. Does the teacher teach with a real purpose? A. E. C.

How State Academies of Science May Encourage Scientific Endeavor among High-School Students. L. A. ASTELL. *Science*, **71**, 445–8 (May 2, 1930).—The state academies may encourage scientific endeavor among high-school students by establishing the necessary organizations (such as science clubs), by supporting detailed information, and by developing momentum for science clubs as activities concerned with the fundamental academic subjects. The academies may promote this work through such specific actions as: (1) making necessary constitutional changes of adult societies as well as high-school clubs; (2) assisting in the development of a constitution for the junior academy; (3) by working through teacher-training courses in science, wherever offered; (4) by obtaining and utilizing to a maximum advantage the periods of time in scientific sections of district, state, and national conferences and associations of teachers; (5) by preparing and distributing literature to the local clubs and schools; (6) by fostering the spirit and methods of science through an intimate knowledge of the men of science, and by the use of their names in identification of clubs; (7) by constructing the annual programs of the state academy for the maximum benefit to the high-school delegates; (8) by supplying lecture service or reprints and other items of direct use in the local programs; (9) by encouraging the use of such devices as purposeful initiations,

cards of credentials, and standardized club pins, and (10) possibly sometime by the employment of a national director. G. H. W.

The Pedagogue and Industrial Chemical Research. D. B. KEYES. *Trans. Ill. Acad. Sci.*, **22**, 403–8 (Apr., 1930).—Research methods now in use in large industrial chemical laboratories are here reviewed. The most common type of industrial research is the invention of a new and better process to produce a well-known product. The fundamental method of attack in all cases of this type analyzed by the author proved identical. An outline of the method is given: (1) A search of the literature. (2) The selection of a possible process with best economic foundation for conditions to be met. (3) List of factors such as pressure, concentration, and chemical characteristics of substances involved. (4) List of all apparent variations of these factors. (5) Selection of the most important factor from the list. (6) Selection of best means of varying this factor. (7) The actual experimentation.

As examples of this type of research procedure the author cites: (1) the development of Dr. Burton's cracking process of petroleum, and (2) the electrodeposition of aluminum on metals. A second type of industrial-chemical research is the development of a new and satisfactory chemical product to take the place of an old product. The common method of attack is outlined: (1) a list of the faults of the old products; (2) a list of similar products not now used for this purpose; (3) a selection from list No. 2 of the most suitable product from an economic standpoint; (4) modification of this product to eliminate as far as possible what faults it has. An example of this type of research is found in the development of rayon.

A third type of research in chemical engineering is the development of a new type of machine to do a unit operation more efficiently than any standard machine has done it previously. This type of research is outlined: (1) a list of all basic requirements of the particular unit process; (2) a list of all apparatus used in other industries for a somewhat similar purpose; (3) a selection from list No. 2 of the apparatus which most nearly meets the basic requirements of the process; (4) modifications of this apparatus to meet the special conditions. As examples of this type of research we have the use of the Haber fixation of nitrogen machine for the manufacture of methanol; the use of metallurgical equipment in the sugar industry; the use of alcohol fractionating columns in petroleum refining, and many others.

Modern industrial chemical research is a highly developed scientific subject, the methods used being almost the same the world over. R. M. P.

A College President's Professional Library. A. M. PALMER. *Assoc. Am. Coll. Bull.*, **16**, 307–12 (May, 1930).—A list of books for a college president, bearing primarily on professional and teaching problems of college administration and teaching. Reprints of the article may be obtained from the office of the Association, 111 Fifth Ave., New York City, at ten cents per copy. G. O.

Some Problems Confronting the Teachers of Elementary General Chemistry. See this title on page 1944.

The Scientific Method in the Study of Education. J. W. WITHERS. *J. Educ. Research*, **21**, 212–23 (Mar., 1930).—This article presents an able discussion of certain problems of educational research in city and state school systems; and the professional education that is essential for the director of this type of research. R. M. P.

A Background for Research. EDIT. *J. Educ. Research*, **21**, 138 (Feb., 1930).—The writer recommends certain source materials in the field of educational research. R. M. P.

Language Requirements for Doctors of Philosophy. See this title on page 1957.

Teaching of Chemistry from the Factory Viewpoint. L. F. NICKELL. *Trans. Ill. Acad. Sci.*, **22**, 377–80 (Apr., 1930).—See digest on pages 1939–41 of this issue of the J. CHEM. EDUC.

Opportunities in Science. See this title on page 1961.

CONTEMPORARY NEWS AND COMMENTS IN CHEMISTRY AND EDUCATION

The Practical Difficulties of Introducing the International Metric System into the United States. W. E. BULLOCK. *Instruments*, **3**, 279–82 (May, 1930).—Perhaps the greatest obstacle in the way of the introduction of the International Metric System into the United States is the lethargy and unconcern of millions of our people. If it should be decreed by Congress that yard, foot, and inch be replaced by the meter, decimeter, and centimeter, and that if barrels were made with a capacity measurement in terms of the metric system, then this would not change the value of the contents of the barrel. To the public the capacity of a barrel would be a barrel whether it was measured in terms of inches or centimeters. The public thinks in terms of pounds and feet and

will continue to think in these terms regardless of the convenience of a metric system. The scale manufacturers are putting out their scales graduated to a high degree of accuracy. The people of the United States have faith in them, and it is quite probable that they have much greater faith in the pound scales than they would have if new metric scales should appear on the counters of the grocery stores. We have achieved too great uniformity, and have done too much standardization in what we now have, to ever contemplate a change in the system. R. L. H.

American Association for the Advancement of Science. See this item on page 1963.

High-School Essay Contest. See item on **American Association for the Advancement of Science** above.

University of Iowa Honors Professor Elbert W. Rockwood. See page 1971.

University of Pittsburgh Honors Professor Silverman. See page 1972.

Professor Karl Johann Freudenberg Appointed Carl Schurz Memorial Professor at the University of Wisconsin. See page 1973.

Institute for Advanced Study. See page 1964.

British Institute of Metals to Meet in America in 1932. See page 1973.

La Dixieme Conférence de l'Union Internationale de la Chimie Pure et Appliquée. See this item on page 1974.

The Albert Medal. See this item on page 1973.

French Society to Preserve Pasteur's Birthplace. See **La société des amis de la maison natale de Pasteur** on page 1975.

James Scott Prize of the Royal Society of Edinburgh Presented to Niels Bohr. See page 1975.

FOREIGN CHEMICAL AND EDUCATIONAL CONDITIONS

Presidential Address to the Chemical Society. J. F. THORPE. *Chem. & Ind.*, 49, 251–8 (Mar. 28, 1930).—The next twenty years will witness an international struggle for supremacy in scientific effort and in application of science which will be even more intense than the struggle between contending nations in the World War. The major portion of the paper is devoted to a discussion of the international problems of the Chemical Society. E. R. W.

International Problems of the Chemical Society, London. See abstract on **Presidential Address to the Chemical Society** above.

GENERAL

Catching Up with Chemistry. T. L. DAVIS. *Rep. New Eng. Assoc. Chem. Teachers*, **31**, 137–45 (May, 1930).—A study of the history of chemistry will give us sympathetic interest in facts and a hospitality of mind which is always ready to weigh and consider. Hypotheses and theories have been judged in the past by the longevity of their usefulness and will continue to be so judged in the future.

The power that moves the procession of chemistry appears to be research. The desire for money does not produce research. There must first be a desire for knowledge, a fascinated questioning of the things which happen. O. C.

Opportunities in Science. B. S. HOPKINS. *Trans. Ill. Acad. Sci.*, **22**, 623–9 (Apr., 1930).—Greater discoveries will be made in the future than have been made in the past. These will be of a different type but the author is convinced that they will add factors to human society that are as vital and as useful as any of the basic discoveries of previous generations.

The author predicts the future by a careful study of the past, and by the way in which problems of other days have been solved. The contribution of Hall to the metallurgy of aluminum, together with the fact of the great work yet to be done in the aluminum industry stands forth as an inspiration to the youth of today. Cottonseed, once a waste product of the cotton industry, has become a valuable part of the crop, the cottonseed industry having become the second largest industry of the South. Scientific problems involved in the coal and coke industries have scarcely been touched and the opportunities in this connection are limitless. Large problems are calling to the scientific worker to eliminate wastes, such as cornstalks and straw on the farm. Already a start has been made toward the utilization of these wastes, for at Danville, Illinois, a high-grade paper pulp is now being made from cornstalks.

In medicine there are many opportunities for the young chemist. For many diseases there are forms of treatment but no specific remedy. This is true of pneumonia, the common cold, pleurisy, goiter, diabetes, sleeping sickness, and many other diseases. New germicides and antiseptics are needed. Much knowledge is needed of hormones, and of ultra-violet light and its influence upon health.

The writer believes there are more opportunities for those now entering the field of

science than have been offered at any previous period of the world's history. The problems outlined will require intense thinking and hard work. It takes a clear mind back of hard work to bring success. Let the young scientist keep his mind clear and his conduct above reproach. R. M. P.

A Suggestion for a Method of Quoting Periodicals. M. SPETER. *Chem.-Ztg.*, **54**, 309 (Apr. 19, 1930).—The abbreviations by means of which the various periodicals are designated in the American, British, and German abstract journals differ widely. This causes a good deal of trouble and misunderstanding. Furthermore, many so-called abbreviations are quite long, *e. g., Abridged Scient. Publicat. Res. Lab. Eastman Kodak Co.* for the *Abridged Publications from the Research Laboratories of the Eastman Kodak Co.* The author suggests that each periodical shall be designated by a number instead of an abbreviation of its name. For example, if the number of the last journal is 1200 and another journal is added, the new journal would be number 1201 and would be listed in its proper alphabetical and numerical place. L. S.

The Pedagogue and Industrial Chemical Research. See this title on page 1960.

Alchemists Flourished in Ancient China. Europe was not the only region of the earth where alchemists plied their secretive trade and marketed their often spurious discoveries. In China, too, this half-disreputable ancestor of chemistry reared its head, so long before European alchemy came into being that Chinese alchemy may well be the ancestor of all the Occidental alchemies. So the Division of the History of Chemistry of the American Chemical Society was told recently by Prof. Tenny L. Davis and Lu-Ch'iang Wu at the Atlanta meeting.

Alchemy seems to have arisen spontaneously in China, where it was certainly in existence as early as the second century B.C. The Chinese alchemists attempted to transmute base metals into gold and to prepare the elixir of immortality. They worked with the same materials that were used by the later Greek, Arab, and European alchemists.—*Science Service*

Fastidious Colors in Gold Produced by Base Metals. Four comparatively common metals—silver, copper, nickel, and zinc—fulfil milady's desire for precious gold in varying blends and shades of yellow, green, and white. Alloying gold not only makes for hardness and produces different karat values but, artistically done, it reveals the precious metal in color schemes, according to Edward A. Capillon, a metallurgist of Attleboro, Mass. "The gold-silver-copper alloys vary in color from light greenish white through green, yellow, and red, depending on the relative amounts of the three metals. Green or yellowish green golds are also obtained by combining relatively large amounts of zinc with gold, copper, and small amounts of silver. The bluish white color of "white golds" depends on the presence in the alloy of both nickel and zinc."—*Science Service*

Distillation Known to Ancient Alchemists. Distillation, one of the most universally discussed of topics since some of its products have been put on the "verboten" list, is no new thing under the sun. Some of its principles were known in ancient times, and in the heydey of the alchemists, during the sixteenth and seventeenth centuries, these old ancestors of the modern chemist knew almost all of the tricks in the trade. So Gustav Egloff and C. D. Lowry, Jr., of Chicago, pointed out before the Division of Chemical Education of the American Chemical Society meeting recently at Atlanta.

The alchemists did not waste all of their time hunting for such fabulous things as the philosopher's stone. They were a practical lot of artists, though their scientific knowledge was sketchy in some departments, and they used apparatus that often had a decidedly modern look for the distilling of all manner of objects, including wood, ores, aqueous and spirituous liquids, flowers, and herbs.—*Science Service*

Local Activities

Purpose and Organization

The purpose of the Local Activities Section of the JOURNAL OF CHEMICAL EDUCATION is briefly but clearly stated in its title. Any items of local news from institutions, A. C. S. Sections, Teachers' Associations, or other organizations which are of such a nature as to make them of more than purely local interest rightfully belong to this Section.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It is desirable to have a representative appointed to report news regularly. Suitable material sent to the editorial office before the 20th of each month will be published in the following month's journal. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the following suggestions are followed, however, the necessity for such action will be largely obviated.

Material to Be Reported

1. Notices of local scholarships or fellowships and announcements of new or unusual courses in chemical education or special fields of chemistry.
2. Reports of dedication of new science buildings, stressing the unique features.
3. News notes concerning activities of prominent scientists and educators and of the honors and awards made to them.
4. Promotions within, or changes of, personnel of a department.
5. Notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.
6. Accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations. Where original or unusual features are included, it is desirable that they be described in some detail.

American Electrochemical Society. According to *Science*, DR. LOUIS KAHLENBERG, professor of chemistry at the University of Wisconsin, was elected president of the American Electrochemical Society at the recent meeting in St. Louis. Other officers elected were BRADLEY STOUGHTON, HUGH S. TAYLOR, and GEORGE W. VINAL, *vice presidents;* D. A. PRITCHARD, M. R. THOMPSON, and ALEXANDER LOWY, *managers;* ACHESON SMITH, *treasurer;* and COLIN G. FINK, *secretary.*

American Association for the Advancement of Science. The Committee on the Place of Science in Education of the A. A. A. S. has announced that the closing date for entries in its high-school essay contest [*see* J. CHEM. EDUC., **7**, 1708 (July, 1930)] has been advanced to March 15, 1921.

Battelle Memorial Institute. The Trustees of Battelle Memorial Institute announce the appointment of DR. O. E. HARDER as an assistant director of the Institute. Dr. Harder is at present in charge of metallography at the University of Minnesota. He is a specialist in physical metallurgy, heat treatment, and allied subjects. Dr. Harder will devote part of his time to the work being conducted at the Institute by the Alloys of Iron Committee of Engineering Foundation.

Dr. Harder has been active in the American Society for Steel Treating, being a member of the National Board of Directors at the present time. He has also been chairman of the Minnesota Section of the A. C. S. and serves on various committees of the American Society for Testing Materials and the American Institute of Mining and Metallurgical Engineers. He is well known in his special fields, having published a great many papers of importance on such subjects as: "Normal and Abnormal Steel," "Metallurgy of Dentistry," "X-Ray Metallography," and "Nitriding."

He received the Howe medal of the American Society for Steel Treating for his researches on the decomposition of the austenitic structure in steel.

The appointment of MR. FLOYD B. HOBART as Fuel Chemist at Battelle Memorial Institute is also announced. Mr. Hobart joins the staff with MR. R. A. SHERMAN, Fuel Engineer, to work under the direction of MR. CLYDE E. WILLIAMS, Assistant Director. This group forms

the nucleus of an organization within the Institute devoted to research problems in fuels.

Mr. Hobart is a graduate in chemical engineering from the University of Illinois where he later taught gas and fuel analysis while obtaining his Master's Degree in industrial chemistry. From 1921 to 1927 Mr. Hobart was on the staff of the Engineering Experiment Station at the University of Illinois as research assistant in chemical engineering where he worked with Dr. S. W. Parr on the constitution, weathering, and carbonization of coal. In 1927 he assumed charge of the semi-plant scale experiments on the Parr process of carbonization for the Urbana Coke Company until 1929. Mr. Hobart comes to Battelle Memorial Institute from the Atlantic Refining Company where he has been chemical engineer in plant experimental and standardization work.

Institute for Advanced Study. The organization of a post-graduate institution under this title, the first of its kind in the United States, has been announced by MR. LOUIS BAMBERGER, formerly head of L. Bamberger and Company of Newark, and his sister, MRS. FELIX FULD. These founders are making an initial endowment of $5,000,000 for the institute, the first director of which will be DR. ABRAHAM FLEXNER, former secretary and director of the General Education Board. The Institute for Advanced Study will provide opportunities for research and the training of advanced students for and beyond the degree of doctor of philosophy or other professional degrees of equal standing. The founders state, in a letter addressed to the trustees, that "many of those who enter the institution will probably qualify themselves for professorships in other institutions of learning, but the institution itself is established not merely to train teachers or to produce holders of advanced degrees. The primary purpose is the pursuit of advanced learning and exploration in fields of pure science and high scholarship to the utmost degree that the facilities of the institution and the ability of the faculty and students will permit."

The trustees of the new institute are: FRANK AYDELOTTE, president of Swarthmore College; EDGAR S. BAMBERGER, Newark, N. J.; DR. ALEXIS CARREL, member of the Rockefeller Institute; DR. JULIUS FRIEDENWALD, Baltimore; JOHN R. HARDIN, Pitney, Hardin, and Skinner, Newark; HONORABLE ALANSON B. HOUGHTON, formerly United States Ambassador to Germany and later to Great Britain; HONORABLE HERBERT H. LEHMAN, Lieutenant-Governor of New York; SAMUEL D. LIEDESDORF, S. D. Liedesdorf and Co., New York City; HERBERT H. MAASS, attorney, New York City; DR. FLORENCE R. SABIN, member of Rockefeller Institute; PERCY S. STRAUS, R. H. Macy and Co., New York City; LEWIS H. WEED, dean of the medical faculty of The Johns Hopkins University.

Mellon Institute of Industrial Research, University of Pittsburgh. The honorary degree of LL.D. was conferred upon EDWARD RAY WEIDLEIN, director of Mellon Institute of Industrial Research, at the commencement of the University of Pittsburgh on June 11, 1930.

Dr. Weidlein has announced, speaking for the Board of Trustees, that the Mellon Institute is to increase its facilities for serving American industries by a building project that will enable the material expansion of all its research activities.

The building, which is to occupy the site of the Institute's Building No. 2, is designed on classical lines, a plain, simple, but massive structure surrounded by columns. It will provide ample space for housing many more Industrial Fellowships than the 63 that now tax the Institute's facilities to the utmost. The other departments of the institution will be increased in proportion.

When the present home of the Institute was completed, in 1915, it was felt that

the Industrial Fellowship procedure created by Robert Kennedy Duncan had passed from the experimental to the practical stage. The building, which was given to the institution by ANDREW W. and RICHARD B. MELLON, incorporated the best laboratory constructional features of that period. It was thought then that it would provide adequate space for growth for many years; but for practically ten years the Institute has had a waiting list of companies, often almost as long as the roster of companies whose problems were being investigated. Even the additional space afforded by Building No. 2, acquired in 1927, gave but temporary relief from the need for more laboratories arising from proposed new investigations and from the necessity of increasing the personnel of fellowships already in operation.

In addition to providing a greatly increased number of laboratories, the new building will give more commodious quarters for the general departments. The present library contains 11,000 volumes; the new library is planned to accommodate 250,000 volumes. The present Department of Research in Pure Chemistry will be expanded and facilities for pure research in other branches of science will be provided. Much more elaborate chemical engineering laboratories are to be available in the new building, and also the fellowships in each specific field of industrial research are to be grouped in suites of rooms so that they can best make use of general apparatus adapted to their needs. Certain rooms will be equipped for specialized phases of experimental technic, such as electrochemistry, spectroscopy, low-temperature studies, radiations, high-pressure experimentation, etc. Other special features to be included are a large lecture hall, a dining hall, an industrial fellowship museum, and an underground garage. For the past five years members of the Institute's executive staff have been visiting important laboratories in America and Europe to obtain information on new features in design and equipment.

The new laboratory structure will be of that type of classical Greek architecture known as Ionic. It is to be seven stories high, with monolithic columns along all four sides. The proportions will be approximately 300 feet by 400 feet. The main entrance, which is located on the third floor, is reached by steps extending along the entire front of the building. The laboratories are to face on interior courts. The design of the new building is to be such that additional laboratory suites can be constructed in the interior courts without marring the beauty of the general appearance and without interfering in any way with the original laboratory units.

Boston University. DR. WILBERT G. A. LINDQUIST, MISS HELEN M. STEVENS, MISS MARGUERITE J. SYNER, and a number of assistants will conduct the courses in chemistry offered by the summer session. DR. MASON will study at the summer school of Cornell University, and PROFESSOR NEWELL and ASSISTANT PROFESSOR E. O. HOLMES will spend the summer at Ogunquit, Maine, the former in writing and the latter in investigating a commercial problem.

Professor Newell has been elected a Fellow of the American Academy of Arts and Sciences.

During the second semester, Professor Newell has brought out a revised edition of two laboratory manuals, one entitled "Experiments in Organic Chemistry" and the other "Experiments in Food and Nutrition." Both are in mimeograph form and are used by his classes in these subjects.

Carnegie Institute of Technology. According to *Science*, DR. HOMER H.

LOWRY, research chemist with the Bell Telephone Laboratories, Inc., New York City, has been selected as director of the recently founded Coal Research Laboratory.

Columbia University. DR. ALAN H. RICHARDSON has resigned as instructor in chemistry and has accepted a position with the Adams Express at 25 Broad Street, New York City, where he will be interested in the financial aspects of the chemical industries.

College of the City of Detroit. DR. WILLIAM V. SESSIONS of the chemistry staff will sail on June 27th to spend the summer in England, France, and Holland.

DR. A. E. REMICK will spend the summer with the research department of the Eastman Kodak Company. Dr. Remick, formerly research chemist for the Todd Paper Company, Rochester, New York, has been with the chemistry staff of the College of the City of Detroit for the past year.

DR. G. RAY SHERWOOD, formerly at James Millikan University, has been for one year on this staff. He will spend the summer at the College of the City of Detroit on research work in the rare earth elements.

The College of the City of New York. At the May meeting of the New York Section of the American Electrochemical Society, PROFESSOR STEVENSON was elected secretary.

Cornell College. DR. N. KNIGHT and DR. J. B. CULBERTSON attended the complimentary dinner to DR. E. W. ROCKWOOD, held at Iowa City, in honor of the completion of his forty-seventh year as professor of chemistry at the State University of Iowa.

DRS. KNIGHT and CULBERTSON and two seniors who majored in chemistry, HARRY DAY and ERNEST NIELSEN, attended the meeting of the Iowa Section of the A. C. S. at Coe College. Dinner was served at the Hotel Roosevelt, after which DR. T. R. HOGNESS of Chicago University gave an address in the physics lecture room of Coe College on "Chemical Physics."

DR. CULBERTSON has a class in organic chemistry and one in organic preparations at the State University of Iowa. Both are largely attended.

THOMAS JACOBS, a senior major in chemistry at Cornell, was initiated into the chapter of Phi Beta Kappa. HOWARD E. SIMPSON, '96, professor of geology at the University of North Dakota, was given the honorary degree of Doctor of Science.

DePauw University. During the past seven years, including this year's class, seventy-eight per cent of the students majoring in chemistry at DePauw have graduated with distinction, and all of these have gone into graduate schools.

MISS ETHEL HERRING has been appointed assistant in chemistry in Greensboro College, filling the vacancy caused by the resignation of MISS ELIZABETH OLIVER.

Hanover College. The Shelby Medal, a gift from MR. W. D. SHELBY, was awarded to MR. CHAS. W. FLEETWOOD this year. It is awarded annually to the senior majoring in chemistry who has the highest standing for the major work in chemistry. Mr. Fleetwood has been appointed as a graduate assistant in the chemistry department of St. Louis University School of Medicine for next year.

Harvard University. TRUMAN LEE KELLEY, professor of education and psychology at Stanford University since 1926, has accepted an appointment as professor of education in the Graduate School of Education, Harvard University.

Dr. Kelley is widely recognized as one of the most distinguished living scholars in the field of statistical and experimental study in education. He has taught

successively at the Georgia Institute of Technology, the University of Illinois, the California public schools, the University of Texas, Teachers' College, Columbia University, and Stanford University. He served as psychological expert for the Commission on Classification of Personnel and member of the Commission on Education and Special Training during the war. He is now serving as psychologist for the Commission on Social Studies of the American Historical Association.

Professor Kelley will offer at Harvard courses in advanced statistical method and a seminar in psychometrics. His special research interest lies in the analysis of mental structure and functions. By the experimental use of tests and statistical procedures he is seeking to isolate and study the basic traits, powers, or abilities that enter as unitary components into the complex processes of learning and conduct. His work is related to that of Dearborn at Harvard, Thorndike and Wood at Columbia, Thurstone at Chicago, and Spearman at London. This group and others are endeavoring to provide a more accurate understanding of the elements that enter into individual development.

Lafayette College. The Lafayette (Alpha Mu) Chapter of Alpha Chi Sigma has been trying to stimulate the interest of beginners in chemistry at Lafayette by offering an annual prize of a silver loving-cup and a set of chemistry books to the student in general chemistry who makes the best record in the course throughout the year. The Chapter will also honor annually the member of the chemistry group of the graduating class who, by vote of the chemistry faculty, is considered to have made the best record and impression throughout his college course, by having his name, etc., inscribed on a plaque of suitable design and permanently installed at a conspicuous place in the chemistry building. At the end of the past college year, the winner of the prize in general chemistry was MARCUS ALLEN NORTHUP of Morristown, N. J. The member of the graduating class, who, by the unanimous vote of the chemistry faculty, won the honor of being the first to have his name inscribed on the Alpha Chi Sigma plaque was WESLEY SHERWOOD GILLETTE of Westport, Connecticut, who received the degree of B.S. in chemical engineering.

The Edward Hart research fellowship ($500), founded by friends and former students of Professor Hart, emeritus professor of chemistry at Lafayette College, has been awarded for the year 1930–31 to LAURENCE W. SPOONER, B.S., '30, Massachusetts Agricultural College. This fellowship was held during the past year by ROBERT W. WIKOFF, B.S., '29, Lombard College.

The E. I. du Pont de Nemours & Co. fellowship ($750), renewed for the year 1930–31 by the du Pont Co. for special investigations in the plasticity of soft solids, has been awarded to ROBERT A. STEPHENS, B.S. in chemical engineering, '30, Lafayette College. This fellowship was held during the past year by HOLMES J. FORNWALT, JR., B.S. in chemical engineering '29, Lafayette College.

Marquette University. MISS GRACE BALLARD, Milwaukee, Wisconsin, a graduate student at Marquette University, recently read a preliminary report of her experiments with the combustion of nitrocellulose X-ray films before the Radiological Section of the Wisconsin Medical Society. During the course of the past year, Miss Ballard has been conducting experiments with X-ray films as related to the Cleveland (Ohio) hospital disaster of a year ago, which cost the lives of one hundred and twenty-five people.

Miss Ballard declared that hydrocyanic acid was probably partly responsible for the toxicity of the fumes, which consisted principally of the poisonous gases, carbon monoxide, and the oxides of nitrogen. Miss Ballard is working under the direction of DR. HERBERT HEINRICH, of

the Marquette University chemistry department, and DR. H. B. PODLASKY, Mount Sinai Hospital, Milwaukee, Wisconsin.

McKendree College. J. R. AKERS, chief chemist at the East St. Louis, Illinois, plant of the Aluminum Ore Company, was elected a trustee of McKendree College at the June meeting of the college board.

Medical College of Virginia. DR. W. G. CROCKETT has been elected chairman of the Virginia Section of the A. C. S.

MR. FRANK P. PITTS, of the chemistry faculty, is instructor in organic chemistry at the University of Virginia for the summer session.

Millsaps College. MR. GRADY TARBUTTON, who has served for two years as assistant professor of chemistry in Millsaps College, has been awarded a scholarship at Duke University and will work at that institution for the D.Sc. degree. He received the M.S. degree from the University of Iowa last summer, having previously obtained his B.S. degree at Millsaps College.

Mississippi Women's College. The Mississippi Academy of Sciences was organized in March, meeting in conjunction with the Louisiana-Mississippi Mathematical Association on Friday and Saturday, the seventh and eighth, at Delta State Teachers' College in Cleveland, Mississippi. Twenty-five members were enrolled. Officers were elected as follows: MR. G. L. HARRELL, Millsaps College, president; DR. G. H. WOOLLETT, vice president; and DR. J. B. LOOPER, secretary and treasurer, both of the University of Mississippi. MR. HARRELL, DR. LOOPER, DR. C. W. GRIFFIN, of Mississippi Woman's College, DR. L. B. ROBERTS, of Belhaven College, and MR. A. M. DONNELL, of Blue Mountain College, were appointed members of the Council.

Meetings will be held annually. Present indications are that the 1931 meeting will be held at the University of Mississippi or at Jackson, Mississippi. Already several papers, including subjects in biology, chemistry, and physics, are being developed for presentation at next year's meeting.

Among the purposes of the Academy are the encouragement of scientific research to provide opportunity for increased coöperation and fellowship among those having scientific interests though not engaged in research, to render public service in scientific matters and to cooperate with other scientific bodies having similar aims. It is also the aim to encourage membership from high-school science teachers and work generally toward the end that Mississippi high-school science courses of study may be more nearly equivalent in the various high schools and that the high-school graduate intending to take the bachelor's degree in science may enter college with a better high-school mathematical background than hitherto.

Missouri School of Mines. The following graduate assistants have been appointed in the chemistry department for 1930: MR. CLAUDE S. ABSHIER, Evansville College, Evansville, Ind.; MR. THOS. DAY, Carroll College, Waukesha, Wisconsin; MR. J. EDWARD MOCKOBEY, Washington University, St. Louis, Mo.; MR. PHILIP DELANO, M.S., Missouri School of Mines and Metallurgy, as an assistant instructor.

DR. HOWARD L. DUNLAP, professor of organic and industrial chemistry, is acting in a consulting capacity during the summer months for the Phillips Petroleum Corporation.

DR. W. T. SCHRENK, head of the department of chemistry of the Missouri School of Mines and Metallurgy, is teaching in the Missouri University summer session at Rolla.

The following have been appointed to fellowships in the United States Bureau of Mines, coöperating with the Missouri

School of Mines and Metallurgy, at the Rolla station: MR. THOMAS BLENKINSOPP, Purdue University, Lafayette, Indiana; MR. HAROLD MADSEN, Freiberg Mining Academy, Freiberg, Germany; MR. G. V. MARTIN, Missouri School of Mines and Metallurgy, Rolla, Mo.

New Jersey College for Women. See **Rutgers University.**

Ohio Northern University. The department of chemistry is being reorganized. PROFESSOR L. C. SLEESMAN has resigned as head of the department, after twenty-five years of service. He will take up work for the university as a member of the endowment committee. MR. A. M. EWING, instructor, has resigned in order to be able to pursue graduate work at Ohio State University. J. R. HARROD has been appointed as acting head of the department. MR. C. R. BROTHERS, who is a graduate of the University of Indiana, and who has done graduate work at Indiana, Minnesota, and Pennsylvania State College, has been appointed instructor in general chemistry.

At a recent meeting of the Ohio Northern local section of the A. C. S., PROFESSOR C. A. MOREY, of Findlay College, was elected chairman; PROFESSOR H. W. BERRY, of Bluffton College, vice chairman; PROFESSOR J. R. HARROLD, of Ohio Northern University, secretary-treasurer, and DEAN R. H. RAABE, of Ohio Northern College of Pharmacy, councilor.

The Ohio State University. The following graduate students have been added to the Junior Staff of the Department of Chemistry for next year: A. A. ALBERTS (University of Oklahoma); L. P. BIEFELT (Denison University); C. L. BERNIER (University of Montana); J. COMPTON (Howard College); E. W. COOK (University of Arkansas); O. C. DERMER (Bowling Green College); D. H. DAWSON (Drexel Institute); K. A. DETLING (Miami University); D. F. HELM (Denison University and Michigan State College); E. O. LONG (Catawba College); MARY A. MAGILL (Ohio State University); J. J. O'BELL (Ohio State University); J. A. PURINTON, JR. (Brown University, University of West Virginia, and Denison University); V. L. RICKETTS (State College of Washington); E. H. SPERRY (Toledo University); D. R. SWAN (Toledo University); J. E. WELLS (University of Mississippi) H. K. WINTER, (Muskingum College); H. WOLTHORN (Hope College).

DR. W. C. FERNELIUS sailed for Germany on the Holland-America Line on May 13th. He will spend a portion of his time with Professor Kasimir Fajans on the study of the physical chemistry of solutions, particularly from the ammonia solvent standpoint. Dr. Fernelius will also be present for most of the meeting of the Tenth Conference of the International Union of Pure and Applied Chemistry at Liége.

PROFESSOR J. F. LYMAN, of the agricultural chemistry department, attended his class reunion at Amherst College the week of May 9th.

DR. R. W. SHUTT received his degree in chemistry at the June convocation and has accepted a research position with the E. I. du Pont Company at Wilmington, Delaware.

DR. WEN-WEI HUANG received his Ph.D. degree in chemical engineering at the June commencement. He sailed for his home in Canton, China, about the middle of July, where he plans to enter water service work or an industrial research organization.

Word has been received from Chekiang, China, that MING-TAN HSIEH, who received his M.Sc. degree in chemical engineering at this University in 1929, has been made a major in the Chinese Army. He is now assisting in the training of the new soldiers in the Province of Chekiang and is stationed at Hangchow, the capital of Chekiang Province.

PROFESSOR J. E. DAY addressed the Ohio Bell Telephone Company Employees Association of Columbus on

June 11th on Electrons and Modern Electrical Signs.

Ohio Wesleyan University. The new head of the department of chemistry will be DR. WILLIAM A. MANUEL. DR. G. R. YOHE, research chemist with the Goodyear Rubber Company of Akron, Ohio, will come to Ohio Wesleyan in the fall as assistant professor of chemistry, in charge of the work in organic chemistry. DR. HARRY F. LEWIS, who has had this work, has resigned to become professor of organic chemistry at the Institute of Paper Chemistry, Appleton, Wisconsin. MR. R. V. SINNETT, who has been an instructor in the department this year, has been advanced to the rank of assistant professor and will have charge of the courses in analytical chemistry.

Rutgers University. The Cooper Logic Examination, which is open to all seniors of sufficiently high scholastic standing, was won by HUGH HELLER of the chemistry curriculum. Mr. Heller is the first chemistry student to win this prize since MR. (now Doctor) JOSEPH COSTA received it in 1921. The prize is $250.00 in cash.

The chemistry department of the New Jersey College for Women has established an honors curriculum similar to the Swarthmore plan. The honors students are examined by chemists from other institutions. The examiners for the present year include DR. F. H. GETMAN and PROFESSOR J. M. NELSON of Columbia.

University of Colorado. HENRY KARL STAEHLE and JOHN JAMES MCKINLEY have recently been awarded research fellowships in chemistry in the graduate school.

University of Chicago. Past and present Chicago students of DR. F. C. KOCH met at his home the evening of April 11th to welcome him back from his recent European trip.

Kappa Mu Sigma, graduate women's scientific fraternity, held its initiation banquet Wednesday evening, April 30th, at Ida Noyes Hall. Members-elect include ADELINE BLOODGOOD, HENRIETTA DA COSTA, LUCY FLOCK, MILICENT HATHAWAY, LESLIE HUDSON, MARTHA JOHNSON, ROSALIND KLAAS, TERUKO NAKAMURA, M. PLIMMER, and BEATRICE SHEEHAN; associate member, BARBARA KNAPP.

The department of physiological chemistry has received a grant for the coming year from the National Research Council for the study of sex hormones. Part of the fund will be used for chemical studies, and part for biological work to be done with the coöperation of other departments.

DR. T. R. HOGNESS spoke before the Iowa Section of the A. C. S. at Cedar Rapids, Iowa, May 16th, on Chemical Physics.

MR. KENNETH ADAMS has been appointed an instructor and curator in the department of chemistry.

University of Cincinnati. Appointments for 1930–31 in the departments of chemistry and chemical engineering are: *Lloyd Fellow*, R. D. GERWE, M.A. (Cincinnati); *Twitchell Fellow*, R. J. BUTZ, M.A. (Yale); *Baldwin Fellows*, J. W. PRICE, M.A. (Cincinnati); E. C. PAYNE, A.B. (Butler); *Laws Fellow*, H. LINFORD, M.A. (Washington State); *Graduate Assistants*, M. BARNETT, A.B. (Butler); P. E. BURCHFIELD, B.S. (Franklin and Marshall); T. CROUCH, B.S. (Converse); W. U. CULP, B.S. (Notre Dame); L. GERMAN, M.A. (Lafayette); J. M. HERSH, B.S. (Purdue); E. HESS, B.A. (Cincinnati); F. R. HOLDEN, B.S. (Hobart); V. M. HOVEY, B.S. (Penn State); E. JUTERBOCK, B.S. (Cincinnati); H. L. KAHLER, B.S. (Franklin and Marshall); H. J. LESSER, B.S. (Georgia); K. MILLSTEAD, B.S. (Kirksville); W. A. MOOMAW, B.S. (Virginia); D. J. PELLETIER, B.A. (Grinell); F. R. RUSSELL, B.A. (Cincinnati); J. F. TREAN, A.B. (Indi-

ana); C. R. WIMMER, M.A. (Ohio State).

University of Illinois. Several new industrial fellowships have been established at the University of Illinois for the coming year. Those firms which have been supporting fellowships for research along certain lines during the past year have all voted to continue the work which is in progress. The Cold Metal Process Company has established a research fellowship for the purpose of studying the rolling and heat treatment of metals. It carries a stipend of $1200, is tenable for one year, and has been granted to MR. W. A. SISSON for the coming year.

The Bauer and Black Company has established a fellowship for 1930–31 for fundamental X-ray research on problems and materials involved in the manufacture of surgical supplies. MR. P. S. STAMATOFF is the recipient of this $750 fellowship.

The F. C. Huyck and Sons Company of Albany has established a fellowship, to be designated as The Frank J. McGovern Research Fellowship, for the fundamental study of the structure of woolen fibers by X-ray diffraction and related methods. MISS HENRIETTA HAYDEN has been granted this fellowship for the year 1930–31, the stipend being $1200.

The Standard Oil Company of Indiana has decided to continue the research which they have been sponsoring on the reactions which take place within the internal combustion engine. MR. H. A. SMITH has been the recipient of this fellowship since its establishment, and will continue on the same problem for the coming year.

PROFESSOR B. SMITH HOPKINS, who has been on leave of absence for the past year, has resumed his duties as chairman of the division of inorganic chemistry. Professor Hopkins spent the year in Southern California. He completed the manuscript for his new textbook, "General Chemistry for Colleges," during his absence. He also studied the teaching methods used by the various colleges and universities on the coast during his visit in that section. PROFESSOR L. F. YNTEMA has been acting chairman of the division in Dr. Hopkins' absence. He will go to St. Louis University in the fall, as professor of chemistry and director of the department.

The persons completing their doctorates in June and August have accepted positions as follows: R. W. BALL and D. D. COFFMAN will be at the du Pont Experimental Station, Wilmington. S. S. ROSSANDER will be at the Jackson laboratory of the du Pont Company. S. M. TROXEL will become a member of the du Pont Rayon staff, and W. A. NICHOLS will be with du Pont Ammonia at Charleston. MISS LUCY PICKETT will join the chemistry staff at Mount Holyoke and MISS RUTH ELLIS will become a member of the Vassar chemistry staff. E. E. BROWNING and EARL JOHNSON have accepted positions with the A. O. Smith Company of Milwaukee. M. E. CUPERY will return to his position as instructor at the Massachusetts Agricultural College. CHESTER BENNETT will be an instructor at the Western Illinois State Teachers' College at Macomb, Illinois.

MR. H. W. WOODROW has accepted a position as assistant professor at the University of Redlands, Redlands, California, and will take up his new duties at the beginning of the fall semester.

University of Iowa. PROFESSOR H. F. LEWIS, of Ohio Weslyan University, is giving a special course in organic chemistry at the University of Iowa during the summer.

The faculty, students, and alumni of the chemistry department of the University of Iowa held a formal banquet on the evening of May 27th in honor of PROFESSOR ELBERT W. ROCKWOOD who has just completed his forty-seventh year of service in that department. A bronze bust of Dr. Rockwood, to be

placed in the foyer of the chemistry building, was presented by his former students and colleagues. A feature of the occasion was the presentation to Dr. Rockwood of a bound volume of letters from his former students, expressing their appreciation of his work and their indebtedness to him.

University of Notre Dame. The final meeting of the year for the St. Joseph Valley section of the A. C. S. was held in Chemistry Hall on May 21st. Addresses were presented by MESSRS. F. J. LISCOMB and P. R. LYONS of the Hanson Van Winkle Munning Co. of Chicago. Mr. Liscomb spoke on "Electroplating," and Mr. Lyons on "Electroplating Mechanics."

Officers who are to serve during the next school year were elected at this meeting. They are as follows: DR. H. D. HINTON, chairman; MR. A. J. GEHRAND, vice chairman; MR. M. F. TAGGART, secretary; DR. E. G. MAHIN, treasurer; DR. H. H. WENZKE, member-at-large. DR. J. A. NIEUWLAND is councilor for the section.

Some of the degrees conferred in chemistry and chemical engineering at the June convocation were as follows: *Ph.D.*—H. D. HINTON: Thesis—"I. A New Method of Preparing Acetals. II. Acetals of Mono-Hydric Alcohols;" FRANK J. MOOTZ: Thesis—"Further Study of the Action of Ferro-Alloys When Mixed with Carburizing Materials;" E. J. WILHELM: Thesis—"A Metallographic Study of the Structure of Small Amounts of Copper and Mercury upon the Corrosion of Lead by Sulfuric Acid;" *M.S.*—W. B. SHANLEY: Thesis—"Factors Affecting the Efficiency of the Generation of Steam;" R. A. WEPPNER; Thesis—"Thermal Conductivity of Condensing Vapor Films."

DR. H. D. HINTON has accepted an assistant professorship in chemistry at Notre Dame.

DR. F. J. MOOTZ has begun work with the Reilly Laboratories Company of Indianapolis, Indiana.

DR. E. J. WILHELM will be connected with the New Jersey Zinc Company at their plant at Palmerton, Pennsylvania.

W. B. SHANLEY and R. A. WEPPNER have accepted positions with the Universal Oil Products Company of Chicago.

The following men who received their B.S. degree at the June convocation have been appointed assistants in the department of chemistry, and will work for higher degrees: W. H. HAMILL, J. E. NELSON, M. M. OTTO, F. J. SOWA.

The University of Pittsburgh. On Friday evening, June 6th, over two hundred chemistry alumni, faculty members, students, and friends of PROFESSOR ALEXANDER SILVERMAN, head of the department of chemistry of the University of Pittsburgh, gathered at a banquet

in his honor, in Webster Hall, to celebrate his completion of twenty-five years of service in the University. A portrait of Professor Silverman, by ELLIS M. SILVETTE, was presented to the University on this occasion, and he was personally presented with a suitably engraved wrist watch in memory of the occasion.

On Wednesday, June 11th, at the commencement exercises of the University,

held in Syria Mosque, the honorary degree of Doctor of Science was conferred on Professor Silverman.

University of Wisconsin. According to *Science*, PROFESSOR KARL JOHANN FREUDENBERG of the University of Heidelberg, and a member of the staff of foreign editors of the JOURNAL OF CHEMICAL EDUCATION, has been appointed Carl Schurz Memorial Professor at the University of Wisconsin for the second semester of the coming school year, beginning on February 9, 1931. Professor Freudenberg's chief researches have been along the lines of the chemistry of the tannins; lignins and cellulose; sugars; insulin; and stereochemistry. He will give two series of lectures on selected topics in advanced organic chemistry and will take a few well-advanced students for research. Such students should have had previous experience in research in organic chemistry. Applications for permission to do such work should be addressed to PROFESSOR J. H. MATHEWS, chairman of the department of chemistry. The lectures will be open to students who have had a full year's course in organic chemistry.

Winthrop College. MISS JOSEPHINE MANNY has resigned her position in the science department to study for her doctor's degree at the University of Missouri. MISS MARION HIERS has accepted a position as instructor in science at the University of Texas. DR. G. G. NAUDAIN gave an address on May 23rd to the militia of York County, South Carolina, on "Chemical War Gases and Their Manufacture."

Wittenberg College. DR. M. P. MATUSZAK, assistant professor of chemistry at Wittenberg College, has resigned his position to work at the United States Bureau of Mines. His place will be taken during the summer session by DR. L. A. WEINLAND, head of the department of chemistry of Otterbein College, Westerville, Ohio. His successor for the coming academic year has not yet been elected.

Iowa Section, A. C. S. The Iowa and Ames Sections of the A. C. S. met with the Iowa Academy of Science at Ames, May 2nd–3rd. Twenty-four papers were presented. The Annual Research Grant was given to PROFESSOR PETERSON of the chemistry department and PROFESSOR WELD of the physics department, both of Coe College.

The May meeting of the Iowa Section was held at Cedar Rapids. DR. T. R. HOGNESS of the University of Chicago made the address on chemical physics.

FOREIGN

The Albert Medal. According to *Nature*, the Albert medal of the Royal Society of Arts for the current year has been awarded by the council, with the approval of the president, H. R. H. the Duke of Connaught, to PROFESSOR HENRY E. ARMSTRONG "for his discoveries in chemistry and his services to education." The medal was founded in 1863 as a memorial to Prince Albert, for eighteen years president of the Society, and is awarded each year "for distinguished merit in promoting arts, manufactures, and commerce."

British Institute of Metals. According to *Metals & Alloys*, plans for an American Meeting to be held by the British Institute of Metals in the United States and Canada two years hence, are now taking definite shape. The reception committee of the Institute's hosts in the United States—the American Institute of Mining and Metallurgical Engineers—has prepared such an attractive program that nearly 100 British members have already booked for the trip. The visit will include official meetings of the Institute in New York, and joint meetings with allied soci-

eties in Detroit and Toronto. Other cities in the itinerary include Pittsburgh, Cleveland, Chicago, Niagara, and Montreal, where plants will be visited. The party is expected to leave Southampton on September 3, 1932. The meeting in New York will begin on September 11th, and the return journey will start from Montreal on September 30th.

Faraday Centenary Celebrations. We quote the following from *The Chemical Age:* "A few years ago Michael Faraday's achievements in chemistry, especially his isolation of benzene, were fittingly celebrated by the Royal Institution. On August 29, 1831, in the course of experiments on the induction of electric current, he made the discovery which led to the dynamo and became the starting point of the use of electrical power and the basis of the electrical industry. Next year, appropriately on the initiative of the Royal Institution, with the coöperation of the Institution of Electrical Engineers and other bodies, the centenary will be celebrated of one of the most important and fruitful experiments in physical science. In addition to the Royal Society and the British Association, it is satisfactory to find that chemistry will be represented in these celebrations, for Faraday's chemical researches, his work on the condensation of gases, his isolation of benzene, and his establishment of the laws of electrochemistry were scarcely less notable than his purely electrical discoveries. Among the coöperating bodies are the Physical Society, the Chemical Society, the Faraday Society, the British Science Guild, the Institute of Physics, the Society of Chemical Industry, the Department of Scientific and Industrial Research, and the Chemistry Research Board."

The Faraday Society. According to *Nature,* The Faraday Society will hold a general discussion on "Colloid Science Applied to Biology" at Cambridge on September 29th–October 1st. A number of workers have been invited to prepare reports on the physico-chemical problems which are encountered in biological work and especially in the study of living matter. These reports will be circulated as far in advance of the meeting as possible so that they may be fully considered by workers in the fields of physical chemistry and biology, and so that considered contributions may be made to the discussion in due course. SIR WILLIAM HARDY will preside over the first part of the meeting, devoted to "Equilibrium in Protein Systems" and will give an introductory address. Those invited to present reports are PROF. A. V. HILL, DR. R. A. GORTNER (Minnesota), PROF. E. J. BIGWOOD (Brussels), and PROF. W. PAULI (Vienna). SIR GOWLAND HOPKINS will preside over a discussion on "The Structure of Living Matter" and will give an introductory address. The following have been invited to give reports: DR. WILMER (Cambridge), PROF. W. H. LEWIS (Baltimore), PROF. R. A. PETERS (Oxford), PROF. FREMIET, PROF. HANS PFEIFFER (Bremen), and DR. J. H. QUASTEL (Cambridge). The discussion should prove of considerable interest and the following prominent workers, more particularly in the field of physico-chemistry, have already accepted invitations to take part: PROF. E. F. BURTON (Toronto), PROF. J. DUCLAUX (Paris), PROF. H. EULER (Stockholm), PROF. H. FREUNDLICH, (Berlin-Dahlem), PROF. H. R. KRUYT (Utrecht), PROF. WO. OSTWALD (Leipzig), PROF. WO. PAULI (Vienna), PROF. S. P. L. SØRENSEN (Copenhagen), and PROF. T. SVEDBERG (Uppsala).

La Dixieme Conférence de l'Union Internationale de la Chimie Pure et Appliquée. The tenth conference of this association will meet at Liége, Belgium, September 14–20, 1930. The following bodies will meet during the sessions: Commission on the Chemical Elements, Commission on the Reform of the Nomenclature of Inorganic Chemistry, Commission on the Reform of the Nomenclature of Organic Chemistry, Commission

on the Reform of the Nomenclature of Biological Chemistry, International Bureau of Physico-Chemical Standards, Commission on Thermochemical Data, Commission on Tables of Constants, Committee on Physico-Chemical Symbols. Some of the papers which will be presented at the scientific sessions are: Resumé historique de la chimie des oses depuis Fischer, GABRIEL BERTRAND (Institute of France); Ring Structure in the Mono- and Polysaccharides, W. N. HAWORTH (University of Birmingham); Relations between Rotatory Power and Constitution of Sugars, CLAUDE HUDSON (U. S. Public Health Service, Washington, D. C.); Mutarotation, T. M. LOWRY and DR. SMITH (University of Cambridge); Constitution de l'amidon, A. PICTET (University of Geneva); Poids Moleculaires des Polysaccharides, H. PRINGSHEIM (University of Berlin); Applications de Rayons X a l'Étude de la Structure des Polysaccharides et de leurs dérivés, PROFESSOR MARK (I. G. Farbenindustrie Ludwigshafen); Propriétés de la cellulose au point de vue des application, EMIL HAUSER (Hawkesbury, Canada); Problèmes concernant la fabrication de la cellulose et l'analyse des cellulose industrielles, SCHMIDT NIELSEN (Trondheim); État colloïdal de la cellulose et de ses dérivés, N. DUCLAUX (Pasteur Institute, Paris); Propriétés physiques des Soies artificielles (relations entre les propriétés des fibres textiles et leurs matières premières suivant leur préparation), ETTORE VIVIANI.

La société des amis de la maison natale de Pasteur. The existence of a French organization under this title has been called to the attention of the JOURNAL OF CHEMICAL EDUCATION by MR. A. P. BLACK of the University of Florida, a member of the staff of contributing editors of the JOURNAL. The association was formed on December 27, 1927, the 105th anniversary of the birth of Pasteur, to assist in the preservation of the house at Dole which was the birthplace of the eminent scientist. M. A. VENTARD, 11 Avenue de la Gare, Dole, France, is the president of the society and the Mayor of Dole and M. RENÉ VALLERY-RADOT, the son-in-law and biographer of Pasteur, are the honorary presidents. The society admits *membres donateurs* at a minimum subscription of 1000 francs, *membres perpétuels*, at a minimum subscription of 100 francs, and *membres cotisants* at an annual subscription of 10 francs. The Gamma Sigma Epsilon Fraternity, of which Mr. Black is the recorder, had the honor of being the first American organization to become a *membre donateur* of the society and will have its name inscribed as such on the marble plaque now installed in the Pasteur House.

International Student Exchange. *Science Service* reports that fifty German students studying in the United States and fifty American students studying in Germany are doing as much as diplomacy and foreign trade to help the Fatherland gain the good-will of the world.

This is a thought expressed by DR. ADOLF MORSBACH, a director of research in thirty-three institutions in Germany and head of the German Students Exchange Service, on his arrival in this country recently. He is visiting the United States to discuss the possibility of extending the scope of the Exchange to medical students and to students in their junior years.

University of Rome, Italy. It has been announced in *Giornale di Chimica Industriale ed Applicata* that PROFESSOR NICOLA PARRAVANO, of the staff of foreign editors of the JOURNAL OF CHEMICAL EDUCATION, has been elected president of the Faculty of Science of the University of Rome for the period 1929–31.

Royal Society of Edinburgh. According to *The Chemical Age*, PROFESSOR NIELS BOHR, University Institute of Theoretical Physics, Copenhagen, was recently presented with the James Scott

Prize of the Royal Society of Edinburgh. PROFESSOR SIR E. A. SHARPEY-SCHAFER, F.R.S., the president, occupied the chair and made the presentation, after which Professor Bohr delivered an address on "Philosophical Aspects of the Atomic Theory."

St. Andrews' University, Scotland. It is announced in *The Chemical Age*, that SIR JAMES C. IRVINE, Principal and Vice-Chancellor of St. Andrews' University, is among those nominated by MR. BALDWIN, as Chancellor of the University of Cambridge, for the receipt of honorary doctorates. Dr. Irvine is a member of the staff of foreign editors of the JOURNAL OF CHEMICAL EDUCATION.

Raman Effect. The amount of light that is scattered by a fluid without change in wave-length increases enormously when the substance is in the critical state. Raman himself suggested that an analogous increase occurred with the modified secondary radiation from carbon dioxide, but W. H. Martin afterward obtained negative results with a mixture of phenol and water (see *Nature*, Oct. 6, **1928,** p. 506). The question is important and has now again been attacked by S. L. Ziemecki and K. Narkiewicz-Jodko, in Warsaw. Their work, which is outlined in *Die Naturwissenschaften* for Nov. 8th, was done with the critical mixture of isobutyric acid and water at 24°C., with a powerful mercury arc of special construction for the primary source. The Raman lines due to the acid were found to be present in the scattered light, but their intensity was certainly not more than some 30 per cent above normal, and even this apparent increase may have been due to a heavy continuous background in the secondary spectrum. They point out that this furnishes an experimental proof that the Raman radiation is not coherent. Two further papers on the Raman effect have also appeared in recent issues of the *Indian Journal of Physics*, the third number of the current volume containing an account of an extended series of observations on modified radiation, by S. Venkateswaran and A. S. Ganesan, and the fourth number a useful summary and bibliography of 150 papers on the subject, by Dr. Ganesan.—*Nature*

The Freezing Point of Sulfuric Acid and Strength of Solution. The freezing point of sulfuric acid presents a very interesting study, although the information given here is by no means new. The oil of vitriol of commerce is known as 66° acid, that is, it tests 66° Baumé—the equivalent of 1.835 in specific gravity. At this strength it freezes at minus 29°F. (−29°F.).

Sulfuric acid is extremely hygroscopic, absorbing moisture from the atmosphere with great rapidity. At first a very slight quantity of moisture will raise the freezing point very rapidly until at 60° Baumé the freezing point will be as high as +12°F. Further accumulation of moisture depresses the freezing point to minus 59°F. (−59°F.) when the acid tests 54° Baumé. A further increase in moisture serves to again raise the freezing point to minus 14°F. (−14°F.) when acid tests 46° Baumé. At this point sulfuric acid practically ceases to be hygroscopic.

When the moisture content is increased to the point where the Baumé reading is 33° Baumé, the freezing point is found to be minus 97°F. (−97°F.). From this point the addition of water raises the freezing point rapidly at first and more slowly toward the end, until the point is reached where the acid content is theoretically zero, when the freezing point is, of course, +32°F., the freezing point of water.—*Science Educ.*

Recent Books

The Aluminum Industry. JUNIUS D. EDWARDS, Ch.E., Assistant Director of Research, FRANCIS C. FRARY, Ph.D., Director of Research, and ZAY JEFFRIES, Sc.D., Consulting Metallurgist, all of the Aluminum Co. of America, with the collaboration of a group of experts from the Company's staff. Two volumes. First edition, McGraw-Hill Book Co., Inc., New York City, 1930. **Vol. I. Aluminum and Its Production,** xii + 358 pp. 63 figs., 6 tables. 14.5 × 23 cm. **Vol. II. Aluminum Products and Their Fabrication,** xviii + 870 pp. 344 figs., 122 tables. 14.5 × 23 cm. Per set (volumes not sold separately) $12.00.

The three major authors are men whose training, experience, and actual achievement eminently fit them for the writing of such a book. Because of the backing of the Aluminum Company of America and the collaboration of other experts in the employ of the company, one is assured that no more favorable conditions for preparing a handbook of the aluminum industry could exist. The book seems to fully justify this unusual privilege accorded its authors.

The reviewer does not presume critical judgment of the technical accuracy of such a work but he can testify to the great value of the book in the library of the student or teacher of general and physical chemistry. Many of the chapters are so interesting as to tempt more leisurely reading than the reviewing schedule would permit, and even some of the sections promising least to a teacher prove extremely pleasant and profitable.

The table of contents (separate for each volume) lists from four to over forty sub-titles for each chapter and arranges these in a clear tabulation that shows the outline at a glance. The index (also separate for each volume) seems adequate but not so extended as to be cumbersome. It is the opinion of the reviewer that each volume should have carried the table of contents of both and that continuous paging of the two volumes with a single index, printed in each volume, would facilitate its use as a reference work. The subject matter hardly seems to justify making one volume more than twice the size of the other, although the larger one is not hard to handle; it is a pleasure to open a new book that is so perfectly bound that it will stay open.

The style is not only interesting and clear but is more uniform than one would expect. Sub-titles are in bold type and the less important or highly special sections are printed in smaller type than the balance of the text. The first phrase or sentence usually indicates the content of a paragraph so that skimming is facilitated. References are given as footnotes and are so numerous as to convince one of the thoroughly scholarly background for the often brief and clear statements of the text proper. Extended bibliographies are also printed after some of the more technical chapters.

As stated in the preface, "the general treatment has been along broad lines, except in regard to the production of alumina from the ore. This subject has been treated in greater detail. . . .the available literature has been abstracted and classified with reasonable completeness. . . .original patents and publications have been consulted. . . ." Volume one deals with the history of aluminum, its ores and their treatment, and the production of the metal. In the second volume, dealing with the properties of both the pure metal and its alloys, aluminum products, their fabrication and uses, the sections likely to interest only a few are briefly outlined while such processes as casting and machining are treated in detail.

The preparation of a handbook of a

major industry is a monumental task; its successful completion a real service. Congratulations to the authors, the publishers, and the Aluminum Company of America.

JAMES C. MCCULLOUGH
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In the Realm of Carbon. The Story of Organic Chemistry. HORACE G. DEMING, Professor of Chemistry, University of Nebraska; recently in charge of the Department of Information of Arthur D. Little, Inc. John Wiley and Sons, Inc., New York City, 1930. x + 365 pp. 15 figures. 15 × 23 cm. $3.00.

In the preface the author states: "This book is intended for the general reader who would like to know something of the manner in which organic chemistry grew and developed, and something of its contributions to the comforts and conveniences of modern life. When supplemented by lectures in which general principles are treated more fully than has here been possible, it is also intended to serve as an introductory textbook of organic chemistry for students not specializing in chemistry."

The book is divided into three parts: *Part I.* How the Foundations Were Laid; *Part II.* The Organic Chemical Industries; *Part III.* The Chemical Activities of Living Cells.

Part I is written in a manner somewhat heavier than that which the late Dr. Edwin E. Slosson employed when dealing with theoretical matter. The two chapters dealing with empirical and structural formulas doubtless will prove too heavy for many a "general reader." The task of holding the reader's attention when writing at length about even an absorbing subject like the story of organic chemistry has been made most difficult, because the modern magazine contributor has developed to such a high art the ability of maintaining the reader's interest through every sentence of the few brief paragraphs.

The second intention of the author should be realized with little difficulty. In the concluding chapter Professor Deming writes: "No great prophetic gift is needed to foresee that the chemical progress of the immediate future will compel progress in chemical education. It will be realized that scientific instruction is not a bit more scientific when dry as dust. On the contrary, it will be understood that the teacher who presents scientific facts without any attempt to relate them to the philosophy of science or to human life is one who has failed to think about them. He gives only facts because he has only facts to give. . . Chemistry as a science will constantly become more mathematical, technical, and forbidding; yet chemistry as a cultural subject will ever be more attractively presented, more useful as a part of a general education, and more intimately related to other things worth while." The reviewer recommends most heartily "In the Realm of Carbon" as a reference work for a course in pandemic chemistry.

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The Structure of Line Spectra. LINUS PAULING, Associate Professor of Theoretical Chemistry, California Institute of Technology, and SAMUEL GOUDSMIT, Associate Professor of Theoretical Physics, University of Michigan. Third volume in the *International Series in Physics*, F. K. RICHTMEYER, *editor.* McGraw-Hill Book Co., Inc., New York City, 1930. x + 263 pp. 15 × 23 cm. $3.50.

From almost all points of view, the most outstanding achievement of the quantum theory has been its success in solving the problems of line spectra. Perhaps never in history has science been presented with so many apparently closely related facts in such a puzzling and complex array, and it has been a remarkable intellectual triumph to order these data by relating them to the structure of the atom, at the same time securing a most

profound knowledge of the nature of the atom itself. The present volume gives the picture of these relations as they are found today, while we are rounding out the results of this first great success in interpreting the structure of the atom.

As explained in the preface the book has been written primarily as a textbook of spectroscopy, and as such leaves nothing to be desired. However, it is bound to have a much broader usefulness than that. For example, it ought to serve chemists particularly well both as an introduction to this field and as a reference book. The first author, by the way, is a chemist especially respected for his knowledge of physics and the second a physicist noted among his associates for his knowledge of chemistry. As one might hope, they have maintained a point of view emphasizing the importance of physical facts rather than mathematical forms, an attitude which the chemist should find particularly pleasing. In fact, it almost seems that one could read the book skipping all the mathematical equations and formulas and still get a very clear picture of the relation of line spectra to the structure of the atom. However, warning must be given that this is in no sense an elementary text and that for its intelligent reading one must have a fair knowledge of the modern physical meaning of such terms as quantum, electron, electron orbit, and wave number.

After a brief but lucid introduction on atomic theories and atomic models, the fundamental principles are discussed as applied to hydrogen and alkali-like atoms. We are then introduced to the concept of the spinning electron and are shown the application of the vector model to a number of cases. These are followed by chapters on special topics, such as intensity and polarization of spectral lines, the Pauli exclusion principle and the periodic system of elements, X-ray spectra, and magnetic phenomena. The chapter on X-ray spectra is particularly good in that it summarizes briefly all the fundamentals of spectra. As may be guessed from this list of topics, the book is far from being a royal road to the understanding of this phase of the structure of the atom, but it is a sure road and one full of pleasure to those who enjoy intellectual discovery.

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Physiology and Biochemistry in Modern Medicine. J. J. R. MACLEOD, M.B., LL.D., D.Sc., F.R.S., Regius Professor of Physiology in the University of Aberdeen, Scotland. Sixth edition, The C. V. Mosby Company, St. Louis, 1930. xxxii + 1074 pp. 295 illustrations. 16 × 24 cm. $11.00.

This is the sixth and somewhat enlarged edition of a well-known book. The 103 chapters are divided into the following ten parts: I. The physicochemical basis of physiological processes. II. The blood and lymph. III. The neuromuscular system. IV. The special senses. V. Circulation of the blood. VI. Respiration. VII. Digestion. VIII. The excretion of urine. IX. Metabolism. X. The endocrine organs, or ductless glands. Wherever it is appropriate, anatomical, physiological, biochemical, and pathological contributions have been combined.

The object of this book, as stated in the preface to the first edition, is to correlate the more pertinent advances of the fundamental medical sciences and to place them in perspective for the benefit of the clinician. In the preface to the sixth edition it is stated: "Steady increase in general knowledge, rather than discovery, has been the feature of the advances in physiology during the last three years, so that changes in the present edition are spread throughout the volume."

In attempting to accomplish his purpose Macleod returns from time to time to discuss fundamental principles and this he does in a descriptive manner admirably suited to the more usual mental habit of a student of descriptive sciences. What has been gained is fairly good exposition of the skeletons of principles. What has

been lost is not only the beauty of finished form but the flesh and blood that is steadily becoming the stuff of an ever more scientific medicine.

It is impracticable to discuss the details of this ponderous book or to note all specific errors. However, it is only fair to warn the reader that he should be on guard against careless exposition and, at least in the biochemical sections, against an occasional positive error and failure to develop significance from recent developments. The reader will find the book better adapted to review purposes than to original instruction. The review purpose will be assisted by an apparently careful selection of references—a selection characterized by the predominance of reviews and the more important, older original papers.

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BULLETINS

Science in the Kitchen: The Selection, Care, and Service of Foods. A series of eight radio talks. Radio Publication No. 58, University of Pittsburgh, Pittsburgh, Penna., 1930. ix + 82 pp. 15.5 × 23 cm. $0.60.

For several years research specialists of Mellon Institute of Industrial Research, Pittsburgh, Pa., have delivered series of popular radio talks, broadcast from the University of Pittsburgh Studio of Station KDKA, on recent advances in science. During the past winter the series consisted of eight talks: "The Well-Planned Kitchen," "The Intelligent Purchasing of Foods," "The Care of Food in the Home," "Good Proportions of Foods," "The Uses of Milk in the Home," "Good Meals for the Young Homemaker," "Food for Young Children," and "The School Lunch."

These talks have now been published in booklet form under the title "Science in the Kitchen: The Selection, Care, and Service of Foods." Copies are being sold at 60 cents by the Radio Manager, University of Pittsburgh. Complimentary copies, however, may be obtained by food specialists, domestic scientists, and dietists who make direct application to Mellon Institute.

Pathfinders in Science. Houghton Mifflin Co., Boston, Mass., 1930. 16 pp. 15 × 23 cm.

A booklet designed to furnish teachers with interesting historical and biographical facts regarding science and scientists.

Medical Education and Related Problems in Europe. COMMISSION ON MEDICAL EDUCATION. Office, Director of Study, 215 Whitney Avenue, New Haven, Conn., April, 1930. 200 pp. 15 × 23 cm.

"The chief purpose of the study was to secure information regarding the general features of medical education and licensure (in various European countries) which would be of value in professional education here (in the United States)."

Annual Report of the General Education Board, 1928-29. General Education Board, 61 Broadway, New York City, 1930. xvi + 113 pp. 13 × 20 cm.

This report includes information on the reorganization of the Rockefeller boards, activities for the year 1928–29 in the colleges and universities, in medical, public, and negro education, and in industrial art, and the treasurer's report.

Aluminum Research Laboratories. Aluminum Company of America, New Kensington, Penna., 1930.

This booklet, attractively bound in a black cover decorated and backed with aluminum, describes some of the features of the new quarters of the Aluminum Company of America, the original research staff of which company consisted of Charles M. Hall. It contains excellent illustrations, bringing out forcibly some of the uses being made of aluminum today in architectural decoration and construction.